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The European IoT Hub

Growing a sustainable and comprehensive ecosystem for Next Generation Internet of Things

D4.4: Report on Training Activities

Version 2

Work package	WP 4
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Abstract

This deliverable illustrates the EU-IoT strategy regarding training and mentoring activities, while reporting on the activities that were carried out during the first year of the project's lifetime. The latter include organization of IoT training workshops, the establishment of a catalogue of an IoT training courses, the development of a skills framework, the execution of an IoT skills survey and of the specifications of learning paths for different IoT skills profiles.

Keywords: IoT, Training, Mentoring, Courses, Skills, Seminars, Operator 4.0, Education, IoT Profiles

Document Revision History

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Nature of the deliverable:	R	
Dissemination Level		
PU	Public, fully open, e.g. web	√
CI	Classified, information as referred to in Commission Decision 2001/844/EC	
CO	Confidential to EU-IoT project and Commission Services	

* R: Document, report (excluding the periodic and final reports)
DEM: Demonstrator, pilot, prototype, plan designs
DEC: Websites, patents filing, press & media actions, videos, etc.
OTHER: Software, technical diagram, etc

EXECUTIVE SUMMARY

One of the main objectives of the EU-IoT Coordination and Support Action (CSA) is to support IoT professionals and the wider European IoT ecosystems in their training and skills development activities. In this direction, the project has planned and implemented a series of training and skills development activities that aims at facilitating IoT professionals, IoT organizations and other relevant stakeholders (e.g., educational policy makers) to:

- Access existing IoT-related training resources.
- Understand and educate themselves about mainstream and cutting-edge IoT topics.
- Discovering IoT skills with significant market relevance and assessing their relevant importance for the IoT market.
- Structuring individual IoT skills to wider IoT skills profiles that reflect the skillsets required to fill-in professional roles in the IoT market.
- Identifying learning paths to acquiring the skills of the IoT skills profiles.
- Discovering paths of certified knowledge for specific IoT skills profiles.

To achieve these goals, the EU-IoT project has during the first two years of its lifetime produced the following tangible outcomes:

- **Outcome 1- IoT Training Catalogue**: EU-IoT has already produced an on-line catalogue of IoT training resources (notably IoT courses and training programs), which facilitates the IoT community in the discovery of courses that meet their skills development needs.
- **Outcome 2- Training Webinars**: EU-IoT organized and conducted five (5) online training seminars in cutting edge IoT technologies. The seminars were attended by 100s of IoT professionals within and outside the European IoT ecosystem.
- **Outcome 3 – Skills Framework**: The project has specified a skills framework as a structured collection of IoT-related skills. This framework is a vehicle for understanding the scope of IoT skills, their interrelationships and their potential clustering in skills profiles and training/trainee “personas”.
- **Outcome 4 - Skills Survey**: The EU-IoT skills survey collected feedback from over 100 IoT professionals on the relevant importance of various IoT skills. It is a useful tool for prioritizing IoT skills and for clustering them in various skills profiles based on criteria like popularity and relevance to specific industries.
- **Outcome 5- IoT Skills Profiles and Learning Paths**: EU-IoT is in the process of defining IoT skills profiles and associating them with learning paths. Such skills profiles reflect the skills that must be possessed by IoT professionals that are destined to fill specific roles (e.g., IoT Programmer, IoT Network Engineering). For each skills profile, the project has also defined a learning path over the available pools of resources like the EU-IoT training catalogue.

The present deliverable presents the above-listed outcomes and the activities that led to their production. In essence it reports on the full range of EU-IoT training activities that were carried out during the first twelve months of the project’s lifetime. The deliverable enhances and significantly extends the activities and outcomes that have been presented in an earlier report of the project (i.e., deliverable D4.3), which reported on the training activities of the first year. It is a self-contained document that reports collectively on the full range of the EU-IoT training and skills development activities.

The deliverable also provides an outlook for on-going and future training and skills development activities for the remainder of the project. Specifically, it illustrates the project’s plans to develop “certified” learning paths i.e., paths consisting of certified courses and knowledge. Moreover it

provides an outlook about the project's commitment to pursue the sustainability and wider use of the project's results.

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ABBREVIATIONS

AI	**Artificial Intelligence**
AIoT	**Artificial Intelligence of Things**
AR	**Augmented Reality**
AWS	**Amazon Web Services**
CB	**Coordination Board**
CD	**Continuous Delivery**
CESSDA	**Consortium of European Social Science Data Archives**
CI	**Continuous Integration**
CoAP	**Constrained Application Protocol**
CSA	**Coordination and Support Action**
DataOps	**Data Operations**
DDS	**Data Distribution Service**
DevOps	**Development and Operations**
DL	**Deep Learning**
DLT	**Distributed Ledger Technologies**
DMP	**Data Management Plan**
DSP	**Digital Signal Processing**
EML	**Embedded Machine Learning**
FAIR	**Findable, Accessible, Interoperable, Reusable**
FPGA	**Field Programmable Gate Arrays**
GDPR	**General Data Protection Regulation**
IDE	**Integrated Development Environment**
IoT	**Internet of Things**
IIoT	**Industrial Internet of Things**
IP	**Internet Protocol**
LPWAN	**Low Power Wide Area Network**
LTE	**Long Term Evolution**
M2M	**Machine-to-Machine**
ML	**Machine Learning**
MLOps	**Machine Learning Operations**
MQTT	**Message Queue Telemetry Transport**
NGIOT	**Next Generation Internet of Things**
OPC-UA	**Open Platform Communications Unified Architecture**
ORDP	**Open Research Data Pilot**

PCB	**Printed Circuit Board**
PLC	**Programmable Logic Controller**
RAN	**Radio Access Network**
SCADA	**Supervisory Control and Data Acquisition**
TCP	**Transmission Control Protocol**
WEF	**World Economic Forum**
WSN	**Wireless Sensor Networks**
XR	**Extended Reality**

1 INTRODUCTION

1.1 Project brief and Deliverable Scope

One of the main objectives of the EU-IoT project is to support the EU funded projects segment of the European IoT ecosystem in skills development activities. In this direction, the project is coordinating the training activities of several H2020 IoT projects (notably the activities of the ICT-56 projects) and supporting European organizations in their skills development activities. The project's support is provided through the development of training resources such as an IoT training catalogue and IoT training materials, the organization of training webinars in cutting edge IoT topics, as well as the provision of support in identifying and structuring skills profiles and learning paths leading to these profiles. These activities fall in the scope of task T4.2 of the EU-IoT project workplan, which is devoted to training and mentoring activities for IoT skills development. The activities address the skills development needs of different types of organizations of the IoT ecosystem, including vendors and integrators of IoT solution, end-users of IoT solutions, policy makers, as well as research and training organizations.

The present deliverable reports on the training activities of the EU-IoT CSA (Coordination and Support Action) that were carried out during the first two years of the project's lifetime. Therefore, it extends and enhances an earlier report on the training activities of the project i.e., deliverable D4.1.

1.2 Purpose and scope of the document

The deliverable provides information on the training activities of the project, including:

- The development of a catalogue of available IoT-related training courses, which has been published on-line in the NGIoT/EU-IoT web site. The catalogue is a useful resource for organizations interesting in discovering IoT-related courses within prominent course and learning ecosystems such as Coursera and Udemy.
- The organization and delivery of training webinars in cutting edge IoT topics, such as the execution of Machine Learning and Artificial Intelligence (AI) systems on IoT devices, and the development of decentralized IoT applications based on distributed ledger infrastructures. These webinars helped in training 100s of participants from the European and global IoT ecosystem. They also produced additional training materials that are available through the NGIoT/EU-IoT web site.
- The production of an IoT skills framework i.e., a taxonomy of IoT skills. The latter is destined to serve as a tool for IoT training, skills development and policy making activities.
- The execution of an IoT skills survey that helped us identify IoT skills with significant traction in the market.
- The clustering of IoT skills into entire skills profiles and the initial specification of learning paths that could help trainees target these profiles. Some of the above-listed EU-IoT resources like the training catalogue and the skills survey can be used to drive the development of skills profiles and learning paths.

The deliverable provides detailed information (including facts and figures) about the above-listed activities. It also explains the overall training strategy of the project and how this strategy is served by the above-listed resources.

1.3 Updates and Enhancements to the Previous Version

The current deliverable has been developed as self-contained document i.e., it does not depend on the previous version i.e., D4.1. It reports on the full range of training activities of the project, including the activities (e.g., seminars) carried out during the first 12 months of the project, which have already been reported in D4.1. To this end, some parts of D4.1 are included in the present document. In particular, the present deliverable includes the following information from D4.1:

- A summary of the training strategy of the project, which aims at providing the context of the deliverable and of the presented activities.
- Information about webinars organized by EU-IoT during the first year of its lifetime. These webinars are also included in D4.2. However, the present deliverable reports on the webinars of the second year of the project as well. It also provides cumulative attendance statistics concerning all the webinars.
- Information about the training catalogue of the project and its integration in the NGIoT/EU-IoT web site.

On the other hand, the present deliverable includes a wide range of activities and information that are reported for the first time. It includes information about the EU-IoT skills framework, the conducted skills survey, as well as the construction of skills profiles and learning paths.

1.4 Structure of the document

This remainder of this deliverable is comprised of the following chapters:

- Section 2, following this introductory section, provides an overview of the project's training and skills development strategy. The strategy facilitates the reader to understand how the different coordination and support activities interact and reinforce each other.
- Section 3 provides information about the IoT training catalogue, including how it was constructed, as well as its purpose.
- Section 4 reports on the training webinars/seminars that were organized during the first two years of the project's lifetime.
- Section 5 introduces the EU-IoT skills framework and the survey that was based on it. It also reports the main results of the survey and explains how these results will be used to support the EU-IoT training and skills development activities.
- Section 6 presents the project's approach to constructing IoT skills profiles and learning paths. It also provides some initial examples that illustrates the approach. Moreover, it provides an outlook for the project's certification activities, which are mainly focused on the connection of existing certifications into learning paths.
- Section 7 is the final section of the deliverable. It draws the main conclusions and provides an outlook for the training activities of the project till the end of EU-IoT's lifetime. These activities will be reported in deliverable D4.5.

2 EU-IOT TRAINING AND SKILLS DEVELOPMENT STRATEGY

2.1 Overview of EU-IoT Training and Skills Development Strategy

The training strategy of the project, including the requirements that have driven the development of this strategy, have been presented in detail in deliverable D4.3. Following paragraphs provide a short overview of the project's strategy regarding the development, offering and use of training resources. In particular, the strategy is driven by the following goals:

- **Facilitating access to existing IoT training resources topics**: Rather than developing courses and materials for themes where many similar resources are available, the project facilitated access to existing resources. This was deemed for more practical and cost-effective than "reinventing the wheel" i.e., developing training materials in areas where many similar materials and training resources are already available. In this direction, the project developed and populated a searchable catalogue of existing IoT courses and training materials[1]. The catalogue includes courses that cover popular IoT topics, such as tutorial introductions to IoT, courses on sensors, sensor boards and Wireless Sensor Networks, courses on IoT programming and courses on IoT analytics. Hence, the EU-IoT catalogue serves as a single access point to searching a pool of IoT courses.
- **Develop and providing training materials in "niche" IoT topics and areas**: EU-IoT has led the development and offering of additional training materials as part of the series of webinars that the CSA has organized and conducted in collaboration with H2020 ICT-56 projects. The webinars focused on advanced IoT topics such as machine learning at the edge, tactile applications using IoT technologies, decentralized IoT applications based on distributed ledger technologies, and 5G-enabled IoT applications. Hence, they provided an opportunity for developing resources in technology areas that are not adequately covered by existing courses materials and training programs. This is perfectly in-line with the mission of H2020 projects on IoT, which aim at advancing the state of the art in the development of IoT technologies and complementary resources such a training. Overall, EU-IoT has collaborated with other H2020 IoT projects (most notably the ICT-56 RIAs) in the development of training presentations, the delivery of webinars, as well as the organization of tutorials and training workshops. The training resources that were produced in the scope of the webinars (e.g., presentations, webinar recordings) have been integrated in the NGIoT/EU-IoT website and complement the resources of the training catalogue.
- **Develop a skills framework and execute a skills survey to identify skills of high demand in the IoT market**: In the area of IoT skills development, EU-IoT introduced a skills framework that provides a taxonomy of IoT skills. The framework enables interested stakeholders to understand the structure and interrelationships of the various IoT-related skills. It also served as a basis for creating an IoT skills survey, which was used to derive IoT professionals' feedback regarding the relevant importance of various skills. Leveraging the framework and the results of the survey, EU-IoT has also produced an initial set of IoT skills profiles. The latter are based on the grouping of a set of relevant IoT skills that can collectively support a professional in successfully filling an IoT role such as IoT developer or IoT data scientist.
- **Development of Integrated Learning Paths:** The EU-IoT training strategy aims at facilitating professionals in developing the skills required to fill an IoT role i.e., an IoT skills profile. In this direction, the project will specify a set of integrated learning paths for different skills profiles. Each of these learning paths will guide researchers, industry practitioners, domain experts and other stakeholders in developing entire skillsets that

[1] https://www.ngiot.eu/archive-ngiot-training/

correspond to trainee "personas" and IoT skills profiles. The present deliverable presents a set of indicative learning paths. The latter illustrate the process of constructing a learning path for an IoT skills profile based on a pool of available learning resources. A richer set of learning paths for a broader range of IoT skills profiles will be provided as part of deliverable D4.5.

- **Learning Paths Certification:** As already outlined in deliverable D4.3, EU-IoT acknowledges the importance of certified training for the IoT skills development ecosystem. The market appreciates certain certifications and tends to prioritize certified knowledge over the non-certified one. Therefore, EU-IoT aims at certifying some of the presented learning paths through linking them to existing certifications with proven traction in the IoT market. In essence, EU-IoT will be specifying "meta-certifications" that will map to sets of existing certifications, notably to sets of certified courses and training programs.

A high-level overview of the EU-IoT strategy for the development of training programs, materials, courses, and related learning paths is provided in **Error! Reference source not found.**. Moreover, Figure 2 illustrates the connection between IoT skills profiles (i.e., Training "personas") and learning paths. Specifically, a persona comprises various IoT skills, which can be acquired based on a variety of IoT courses. The latter form a learning path that can lead to the skills profile at hand.

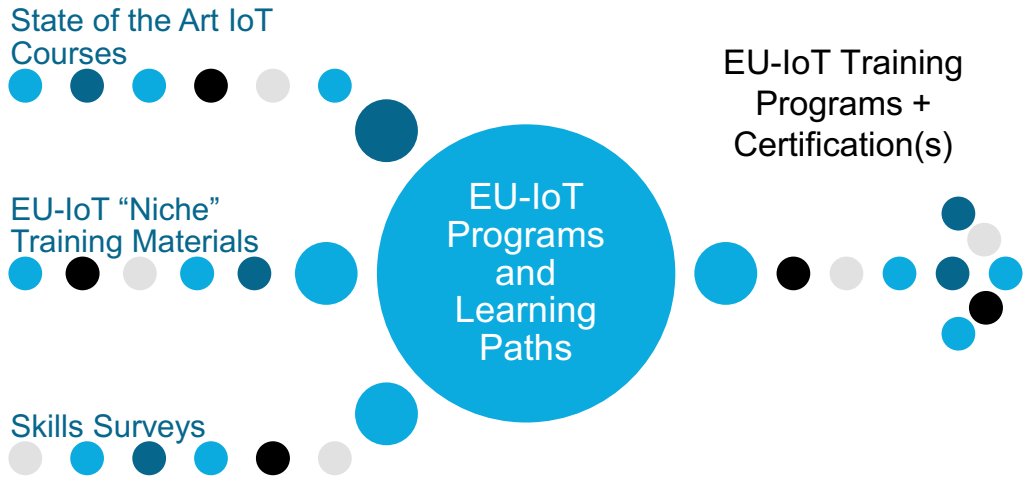

Figure 1: EU-IoT Training Strategy for Access to Training Materials and Resources

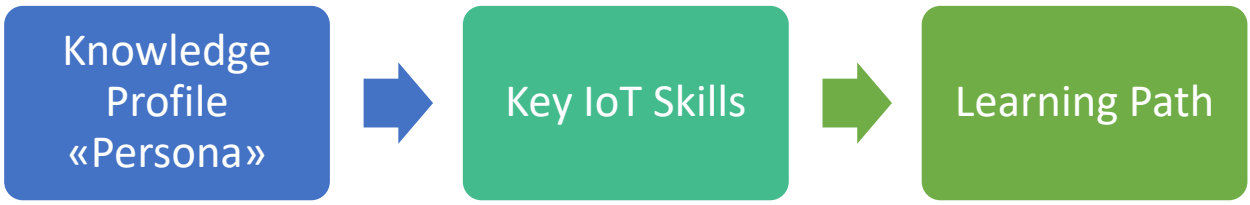

Figure 2: An IoT Learning Path is Driven by the Key Skills that comprise the Knowledge Profile of the Learner ("Persona")

As evident from the above-listed description of the strategic goals of the EU-IoT strategy, there are interdependencies among the various training activities. These interdependencies are purposeful and designed in way that helps one type of activity to reinforce another. For instance, the collection of IoT training resources and their integration in the catalogue facilitates the process of defining learning paths for the various skills profiles. As another example, the EU-IoT framework drove the definition and execution of the IoT skills survey. Likewise, the survey boosts the definition of skills profiles and the specification of related learning paths.

2.2 Main Outcomes of the Training Activities

The (main) tangible outcomes of the EU-IoT training activities can be summarized as follows:

- **Outcome 1- IoT Training Catalogue**: EU-IoT has already produced an on-line catalogue of IoT training resources (notably IoT courses and training programs), which facilitates the IoT community in the discovery of courses that meet their skills development needs.
- **Outcome 2- Training Webinars**: EU-IoT organized and conducted five (5) online training seminars in cutting edge IoT technologies. The seminars were attended by 100s of IoT professionals within and outside the European IoT ecosystem.
- **Outcome 3 – Skills Framework**: The project has specified a skills framework as a structured collection of IoT-related skills. This framework is a vehicle for understanding the scope of IoT skills, their interrelationships and their potential clustering in skills profiles and training/trainee "personas".
- **Outcome 4 - Skills Survey**: The EU-IoT skills survey collected feedback from over 100 IoT professionals on the relevant importance of various IoT skills. It is a useful tool for prioritizing IoT skills and for clustering them in various skills profiles based on criteria like popularity and relevance to specific industries.
- **Outcome 5- IoT Skills Profiles and Learning Paths**: EU-IoT is in the process of defining IoT skills profiles and associating them with learning paths. Such skills profiles reflect the skills that must be possessed by IoT professionals that are destined to fill specific roles (e.g., IoT Programmer, IoT Network Engineering). For each skills profile, the project is also defining a learning path over the available pools of resources like the EU-IoT training catalogue.
- **Outcome 6- "Certified" Learning Paths**: The project will be also specifying certified learning paths i.e., learning paths that are associated with certified courses. Certified learning paths can be seen as "meta-certifications" that combine existing certifications in-line with the needs of skills profiles and learning paths. This is work in progress that will be reported and detailed in the scope of deliverable D4.5 i.e., the next deliverable on EU-IoT's training activities.

These six outcomes serve the goals of the EU-IoT training strategy as illustrated in the following table.

EU-IoT Training Goal	Relevant EU-IoT Outcomes
Ease Access to IoT Training Resources	Training Catalogue (O1)
Provide training resources in "niche" IoT areas	Training Webinars (O2)
Identify IoT Skills e with Market Relevance	Skills Framework (O3) and Skills Survey (O4)
Learning Paths for IoT Skills Profiles	IoT Skills Profiles and Learning Paths (O5)
Boost Certified Knowledge for IoT Skills	Certified Learning Paths (O6)

Table 1: Matching of EU-IoT Training Goals to Outcomes

The outcomes of the EU-IoT training outcomes deliver direct benefits for various stakeholders of the IoT ecosystem, as shown in Figure 3. Specifically:

- **IoT Training Providers** can associate their offerings to specific IoT skills and IoT skills profiles. In this way they can indicate how their courses can support entire training journeys for specific training "personas" and skills profiles. Moreover, they use learning paths to drive the definition of new courses and training programs.
- **IoT Policy Makers** (e.g., ICT skills policy makers) can take advantage of project's collection of training and skills resources to specify educational policies that are well aligned to the requirements of the industry. Likewise, they can analyse information on the available courses towards boosting their evidence-based decision making and taking

educated decisions.

- **IoT Professionals and Interested Students** are provided with easy and flexible access to training resources of the EU-IoT project and other providers. They can attend courses (including certified courses) from different providers to gain the key skills mandated by specific profiles of their choice.

Based on Figure 3, different IoT stakeholders can benefit from the EU-IoT training resources. These benefits are expected to boost the sustainability and wider use of the EU-IoT training resources and results, which is pursued in the scope of WP5 of the project.

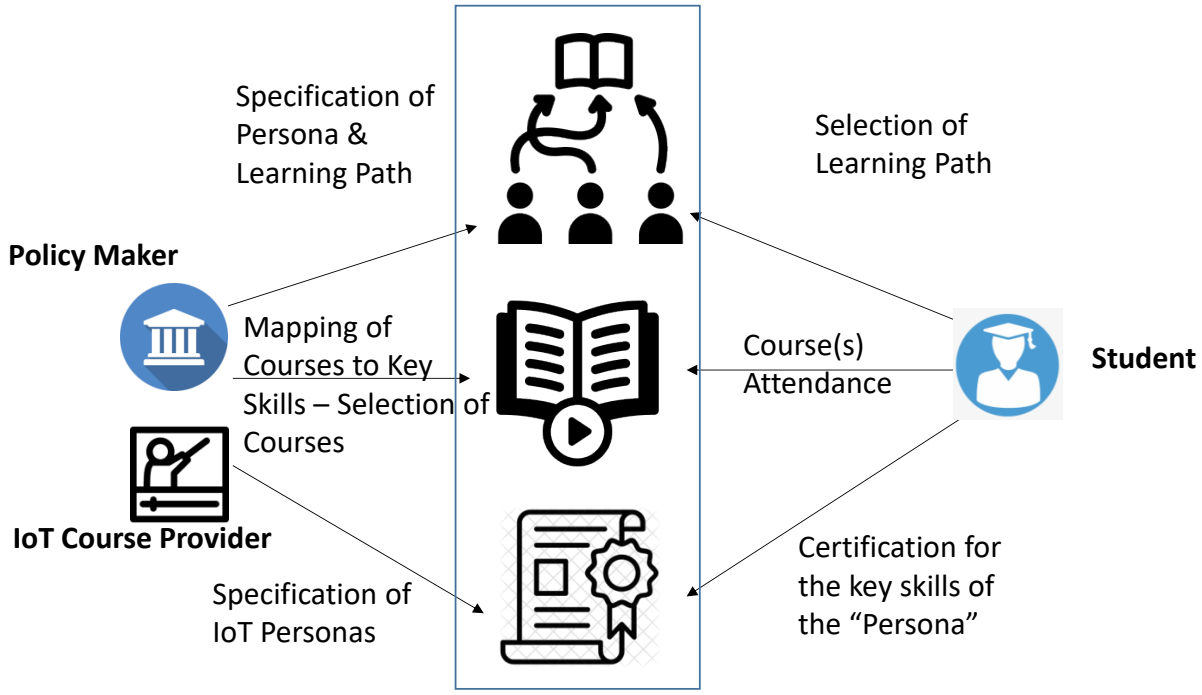

Figure 3: How Different IoT Stakeholders will benefit from EU-IoT's Training Resources

2.3 Interactions and Links with other Activities and Work Areas of EU-IoT

The EU-IoT training activities have greatly benefited from synergies with other WPs of the project. Specifically, they have leveraged inputs from other work packages and have produced results that strengthen other deliverables of the project. Some characteristic examples of these synergies follow:

- **Inputs from WP2 & WP3 on cutting edge IoT topics and technologies**: EU-IoT WP2 and WP3 have provided valuable inputs on future IoT-related research and innovation agendas. These inputs have been accordingly used in the specification of the skills framework and in the planning of webinars. For instance, WP2 and WP3 activities have identified the importance of AIoT (Artificial Intelligence of Things) for the future of IoT systems and services. Therefore, the skills framework of the project has included several AIoT related skills, while two of the webinars included several AIoT related topics like TinyML and embedded machine learning.
- **Training resources complement other outputs of the project in WP2, WP3 and WP4**: The project's training resources (e.g., the EU-IoT training catalogue) complement other

assets developed by the project such as the open-source catalogue and the catalogue of IoT use cases. Specifically, stakeholders with an interest on specific open-source projects and/or IoT use cases in specific sectors can use the training catalogue to locate relevant learning resources.

Overall, the interaction of the training activities with other activities of the project's workplan has been an essential element of the training strategy of the project.

3 EU-IOT COURSES AND TRAINING PROGRAMMES CATALOGUE

3.1 Catalogue Structure

The EU-IoT courses and training programs catalogue is destined to provide a single entry to point to several selected IoT training resources. Specifically, the catalogue includes a critical mass of IoT courses, notably on-line courses from the most popular IoT training ecosystems and platforms, i.e., platforms like Coursera, edX and Udemy. Moreover, it also aggregates courses provided by university and academic institutions. A snapshot of the initial contents of the catalogue is provided in Appendix B. For each course, the following information is recorded:

- **Name/Title**: The title of the course.
- **Short description**: A short description presenting what the course is all about and summarizing its contents.
- **Instructor/Institution**: The provider institution/organization of the course, along with information about the instructor (if available).
- **Provider/Course Platform**: The course platform or ecosystem that facilitates access to the course. Many of the listed courses come from platforms like Udemy and Coursera.
- **Price/Cost**: The price of the cost, when not for free.
- **Duration**: The duration of the course.
- **Keywords**: Metadata that can be used for searching different courses.
- URL: A link to the course dedicated online page/site. With the courses that are integrated into some course platform, the URL points to the web page of the course in the platform.

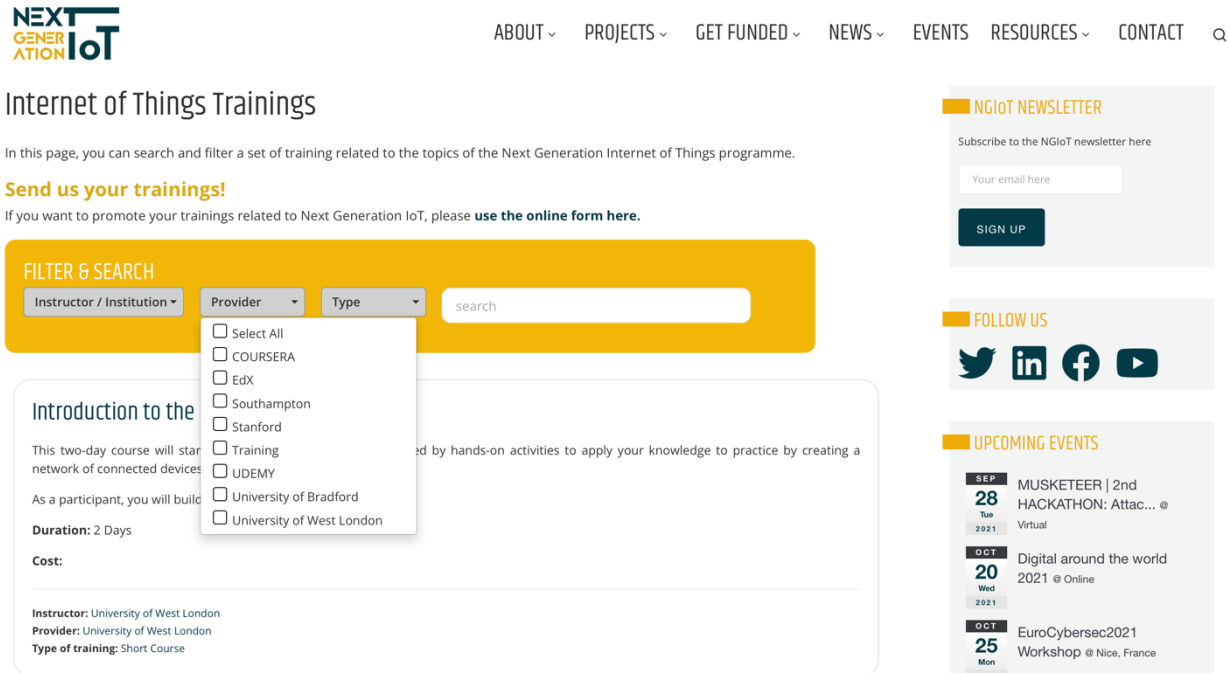

Figure 4: Snapshot of the first version of the Internet of Things Training Catalogue

3.2 Catalogue Implementation

To initialize the catalogue an initial list of approx. 100 courses has been created. The catalogue

is already available in a beta-landing page of the NGIOT/EU-IoT web site with the following characteristics:

- **Searchable**: It will be possible to search courses in the catalogue based on criteria like their topics, cost, and metadata keywords. Searching based on multiple criteria (e.g., price and duration) will be also possible.
- **Extensible**: It is possible to add a new course in the catalogue. To this end, a dedicated form is offered, which enables visitors to the NGIOT portal to propose additions to the catalogue. Additions will be reviewed by the EU-IoT consortium prior to their final integration in the catalogue.

The catalogue of training resources is available at: https://www.ngiot.eu/archive-ngiot-training/

4 EU-IOT TRAINING SEMINARS

4.1 Conducted Seminars

4.1.1 "AIoT and Edge Machine Learning", May 21st, 2021

4.1.1.1 Overview

A seminar titled "AIoT and Edge Machine Learning" was organized on May 21st, 2021 (Figure 5). The seminar aimed at presenting different approaches for AI and machine learning at the edge, such as federated machine learning, machine learning on embedded devices and TinyML. It was performed with contributions from several ICT-56 projects, including ASSIST-IoT, IntelloT, VEDLIoT, iNGENIOUS, IoT-NGIN, beyond presentations from EU-IoT. The agenda of the seminar is provided in Appendix A. Presentations and materials used in the seminar, along with the recording of the seminar, are available in the NGIOT portal and will be also made available in the EU-IoT training page.

4.1.1.2 Attendance

There were 175 registrations for the online event. 100 of them connected to the seminar, with approx. 90 of them connected for almost the full duration of the seminar.

4.1.1.3 Audience Feedback

There was very positive feedback about the seminar, including positive feedback about the quality of the presentations and the organization in general. Such feedback was received during the seminar, but also through social media (e.g., in relevant LinkedIn posts). There were approx. 2-3 questions from the audience in each presentation and relevant discussions followed. In this respect, one comment also concerned the need for allowing more time for discussion after the presentations.

Figure 5: Banner of the "AIoT and Edge Machine Learning" Workshop

4.1.2 "Enabling the Tactile Internet with IoT", July 8th, 2021

4.1.2.1 Overview

A seminar titled "Enabling the Tactile Internet with IoT" was organized on July 8st, 2021 (Figure 6). The seminar aimed at presenting different approaches for Virtual Reality (VR), Augmented Reality (AR) and Extended Reality (XR) IoT applications. Use cases with proper video demonstrations were presented as well. The importance of high-performance networking infrastructures to support the VR/AR/XR applications was adequately explained and emphasized as well. The seminar was organized with the participation and contributions from several ICT-56 projects including ASSIST-IoT, IntelloT, iNGENIOUS, IoT-NGIN, beyond presentations from EU-IoT. The agenda of the seminar is provided in Appendix A. Presentations and materials used in the seminar, along with the recording of the seminar are available in the NGIOT portal and will be also made available in the EU-IoT training page.

4.1.2.2 Attendance

There were 56 registrations for the online event. 48 of them connected to the seminar, and approx. 42 of them were connected for almost the full duration of the seminar. The lower numbers when compared to the 1st seminar were partly due to the period of the seminar (i.e., July 2021) where the availability of European participants was generally lower than in May 2021. This is a trend that was observed in other on-line events as well. Moreover, the topic of the seminar was more specialized than AI and edge computing, and as such address to a smaller audience.

Figure 6: Banner of the "Enabling the Tactile Internet with IoT" Workshop

4.1.2.3 Audience Feedback

There was extremely positive feedback about the content of the seminar: it was pointed out that there are no very widely available resources for AR/XR IoT applications. 1-2 technical questions were received in each one of the presentations and demonstrations.

4.1.3 "Machine Learning at the Edge and the Far-Edge", August 30th, 2021

4.1.3.1 Overview

The seminar was organized in the scope of the online edition of the IoT Week 2021, in collaboration with IoT-NGIN and VEDLIoT. It was held on August 30th 2021 (Figure 7). The content of the seminar was focused on the presentation of different edge machine learning paradigms. In this respect, there were some similarities to the 1st seminar of the series. Emphasis was also paid to cybersecurity issues of Federated Machine Learning (FML), as well as on hardware acceleration issues for edge machine learning. Presentations and materials used in the seminar, along with the recording of the seminar are available through the IoT Week website and will be also made available in the EU-IoT training pages.

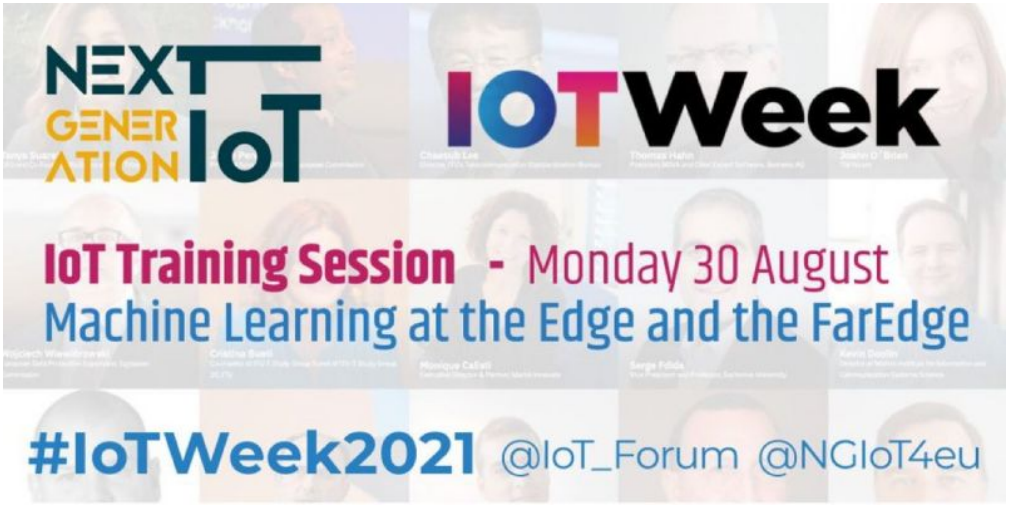

Figure 7: Banner of the "Machine Learning at the Edge and the FarEdge" Workshop held in the scope of the 2021 Online IoT Week

4.1.3.2 Attendance and Feedback

The seminar was attended by over 100 participants, notably IoT Week's registered participants. However, there were no questions and discussion following the presentations, partly due to the limited time allocated to this session. This was a known issue yet imposed due to the constraints of the IoT Week, which offered a very rich and diversified online program.

4.1.4 "Next Generation IoT Architectures", November 9th, 2021

4.1.4.1 Overview

EU-IoT organized a seminar dedicated to next generation IoT architecture. It was aimed at providing information on the evolution of IoT architectures in a more decentralized, scalable, and high-performance direction, leveraging technological developments such as 5G networks and distributed ledger technologies. Specifically, the seminar provided ICT-56 projects with the opportunity to present the architectures of the advanced IoT platforms that they developed. The presentations revealed several commonalities between the architectures of the various projects. Nevertheless, they also helped the audience to identify the subtle differences in the architectures of the various projects, which were driven by differences in the projects' goals and in the

technologies that the projects adopted and used.

The seminar was titled “Next Generation IoT Architectures” was organized on November 9th, 2021 (Figure 8). It was organized with the participation and contributions from all ICT-56 projects including ASSIST-IoT, IntelIoT, iNGENIOUS, IoT-NGIN, TERMINET, and VEDLIoT. The seminar included an introductory presentation by EU-IoT where a pool of standards-based IoT architectures (notably reference architecture models) was presented. The agenda of the seminar is provided in Appendix A. Presentations and materials used in the seminar, along with the recording of the seminar are available in the NGIoT portal and the EU-IoT training page therein.

Figure 8: Banner of the “Next Generation IoT Architectures” Workshop

4.1.4.2 Attendance and Feedback

This seminar was very appealing to the community of ICT-56 projects. This was because it provided all projects with insights on how other projects address similar IoT problems (e.g., structuring of IoT components and building blocks for scalability, efficiency, and ease of use). Hence, most questions aimed at boosting experience sharing and knowledge transfer between different projects. Nevertheless, there were some questions from participants outside the community of ICT-56 projects as well. The latter questions were mostly focused on obtaining more information about the architecture considerations of selected projects, including information on the migration from legacy architectures to emerging ones.

4.1.5 “Decentralizing IoT Intelligence with DLT Technologies", February 7th, 2022

4.1.5.1 Overview

A seminar titled “Decentralizing IoT Intelligence with DLT Technologies” was organised on February 7h, 2022 (Figure 9). It comprised presentations from several ICT-56 projects, including ASSIST-IoT, IoT-NGIN, iNGENIOUS, and TERMINET. These projects presented different blockchain-based use cases decentralized for IoT systems and applications, including DLT systems for cybersecurity auditing and increased security of IoT infrastructures. One of the presentations introduced an inter-ledger solution that spanned multiple complementary blockchains. The webinar included also an introductory presentation by EU-IoT, which summarized the most popular uses of blockchain infrastructures in IoT systems and applications.

Figure 9: Banner of the "Decentralizing IoT Intelligence with DLT Technologies" Workshop

4.1.5.2 Attendance and Feedback

More than ninety (90) participants registered for this webinar, while over forty-five (45) of them attended the workshop. The participants included professionals with either IoT or blockchain backgrounds. The participants exhibited considerable interest in the presentations, which was reflected in the number and the quality of the questions asked. Specifically, the participants asked questions about other potential use cases of blockchain technology in IoT, the benefits of using blockchains and their quantification, as well as about the scalability and robustness of the blockchain infrastructures used.

4.2 Analysis of Participation and Engagement in the Webinars

To assess the impact of the webinars on the EU-IoT community and the wider European IoT ecosystem, information about the number of registered participants in the various webinars was collected and analysed. Table 2 reports the number of registered individuals to each workshop, as well as the number of people that attended each webinar. The webinars attracted a total number of 410 registrants and 344 attendants, not accounting for the webinar that was organized in conjunction with the 2021 edition of the IoT week. These numbers are considered high, when compared to attendance in similar events organized by EU projects. It should be however noted that the quite high numbers were favoured by the COVID19 pandemic period, which led many IoT professionals to participate in virtual events.

Webinar	Registered	Attendants
1. AIoT and Edge ML	176	101
2. Enabling the Tactile Internet with IoT	57	42
3. IoT Week Training – Edge AI	N/A (handled by IoT Week)	N/A (handled by IoT Week)
4. Next Generation IoT Architectures	87	47
5. Decentralizing IoT Intelligence with DLT Technologies	90	48
TOTAL	**410**	**344**

Table 2: Registered Participants and Actual Attendance at the EU-IoT Webinars

There are individuals that participated in two or more seminars. However, each of the seminars

has also its own audience i.e., participants interested in the specific theme of the webinar. Based on an analysis of the registrations, a total of 310 unique participants joined at least one the workshops. Note also that this number, along with the total number of participants and actual attendees are higher. This is because we lack data for the webinar that was organized during the 2021 edition of the IoT week, as registration and event management were carried by the IoT Week and not by the EU-IoT project.

5 IOT SKILLS FRAMEWORK AND SURVEY RESULTS

5.1 Overview of EU-IoT Skills Development Activities

Recent studies have concluded that IoT skills is a catalyst for the accelerated adoption of IoT solutions and for the subsequent growth of the IoT market. This is because the IoT skills shortage is identified as one of the factors that hinder IoT deployments.

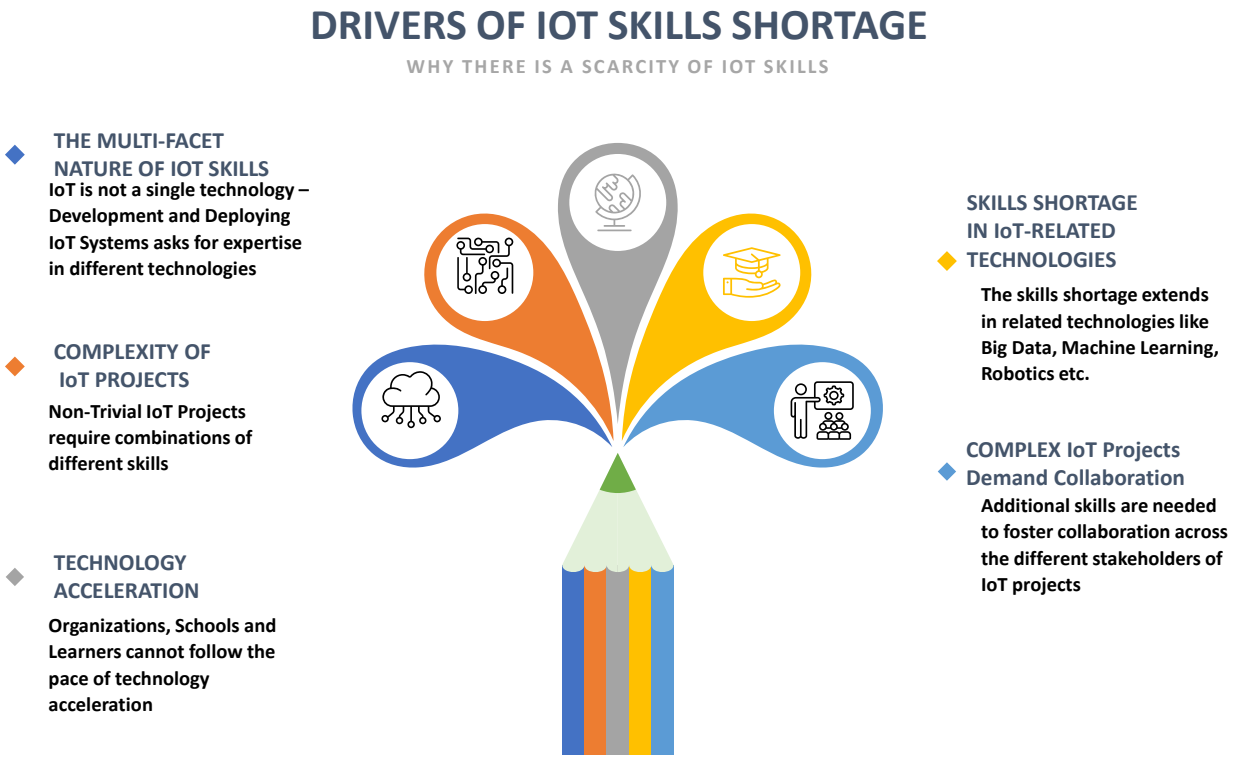

Figure 10: Main Drivers of the IoT Skills Shortage Worldwide

The development of solutions to the IoT skills gap is very challenging for several reasons, including (Figure 10):

- **The multi-facet nature of IoT skills**: IoT is not a single technology, but rather a computing paradigm that integrates multiple technology solutions such as embedded systems, broadband networks, cloud computing, machine learning and cybersecurity. Therefore, most IoT roles are associated with multiple skills from different technological areas. Furthermore, many IoT skills profiles ask for non-technical skills like business development, marketing, and collaboration skills.
- **The complexity of IoT solutions**: During the past decade state of the art IoT solutions have increased in scale and functional sophistication. IoT solutions are no longer a matter of connecting one or a few devices to a network. Rather they comprise multiple technology infrastructures, which have diverse development and deployment requirements. Tacking this complexity asks for IoT professionals with multi-disciplinary profiles and different skillsets that go far beyond the basics of IoT systems.
- **The unprecedented technology acceleration**: Digital technologies are evolving in a rapid pace, which drives a fast-changing IoT landscape. For instance, most IoT-related EU-funded projects cope with technologies like edge intelligence, federated learning, and the tactile internet (e.g., Augmented Reality (AR) and Mixed Reality (MR)). These technologies were hardly available few years ago. This creates a very dynamic IoT landscape, while makes it very difficult for skills development activities to keep up with the

evolution of the state of the art.

- **The skills shortage in related technologies**: As already outlined, IoT projects require skills in cutting edge technological areas like Machine Learning (ML), Artificial Intelligence (AI), and cybersecurity. Each of these technology areas is experiencing its own skills shortage as demand for skilled workers in these areas is skyrocketing. This makes it very difficult to properly staff complex IoT projects.
- **The need for collaboration in IoT projects**: Successful IoT deployments are all about collaboration between different stakeholders and business actors. Hence, they bring together inter-disciplinary and multi-disciplinary expertise, which can be hardly found in modern IoT teams.

To alleviate these challenges EU-IoT has carried out towards the following goals:

- Reviewing the wide array of different IoT skills needed for the development, deployment and operation of modern IoT projects.
- Introducing a skills framework, which includes a taxonomy of IoT skills and serves as a basis for defining skills profiles, education activities and learning paths.
- Organizing and executing a skills survey, which involved over 100 experienced IoT professionals in the specifications of the IoT skills that are currently highly demanded in the market.
- Clustering IoT skills into meaningful IoT skills profiles, notably the profiles that are currently high in demand in the global job market.
- Illustrating how the EU-IoT skills framework and the EU-IoT catalogues of training courses can drive the specification of learning paths for popular IoT skills profiles.

5.2 The IoT Skills Landscape

IoT education and skills are considered a catalyst for the adoption and growth of the IoT computing paradigm. At the same time, IoT skills are considered important for the development, deployment and adoption of a range of related technologies such as Artificial Intelligence (AI) and Cyber Physical Production Systems (CPPS) in the context of the fourth industrial revolution (Industry 4.0). Furthermore, industrial workers must develop IoT skills, given that the Industrial IoT (IIoT) is an integral element of the digital transformation of most industrial organizations in sectors like manufacturing, energy, oil and gas, mining, and healthcare. More generally, IoT skills are important for most jobs and occupations that fall under the broader umbrella of the future of work, which will be characterized by increased automation, transfer of labour-intensive tasks from humans to machines, as well as by increased human-machine collaboration.

The future of work has a very broad scope, as it entails changes in many different jobs across all industrial sectors. Likewise, the future of work requires a broad range of IoT-related skills, which will be part of different job profiles in various industries. Thus, there is a need for identifying and properly structuring the various IoT skills as part of some IoT skills framework. In this direction, many industrial, educational and research actors have attempted to identify, document and structure the wide array of IoT skills. The respective classifications had different aims and objectives, such as employment, recruitment, education planning (e.g., [Richert16]), curriculum development (e.g., [Sackey16]), industrial training (e.g., [Piñol17]), reskilling/upskilling, as well as policy development purposes [VanDeursen21] (e.g., industry / university collaboration [Kumar17]).

Several IoT skills reviews focus on technical and technological skills. This is the case for reviews that aim at analysing the technical skills required for developing and deploying IoT solutions. For instance, [Shacklett21] outlines the importance of programming skills (e.g., Python, C, C#, Java

Script) and of the knowledge of IoT protocols (e.g., MQTT) for IoT development. There are also articles that structure technical skills in more complete IoT profiles like hardware designers, embedded firmware developers, backend developers, frontend developers, IoT application developers, automation and systems integration engineers, as well as data scientists [Dunkels2019]. These roles include profiles that are more general than the scope of IoT applications (e.g., frontend/backend developers). However, IoT's technical jobs and profiles are not limited to hardware and software development. Rather they also cover additional roles like IoT engineers, IoT architects, and IoT researchers [Hiter21].

Nevertheless, the purely technical view of IoT skills is narrow minded. This is evident in policy related studies (e.g., [Kritikos21]), including the European Skills Agenda [COM(2016)381-2016] i.e. Europe's plan to help individual and businesses develop more and better skills. These policy studies underline the necessity of complementary and soft skills. The latter are considered important both for building IoT and automation systems and for alleviating the potential adverse effects of automation in employment. Typical examples of such skills include problem-solving, creativity, communication and persuasion.

Acknowledging the importance of non-technical skills, various skills surveys for IoT, IIoT and Industry 4.0 propose thinking, social and other soft skills as critical elements of IoT education or IoT reskilling for industry professionals [Maisir19]. For instance, [Saniuk21] illustrates skills that must be possessed by IoT professionals in managerial position. Beyond technical skills they identify skills like problem solving, IoT usage, analytical capabilities, communications, life-long learning, management skills, teamwork, openness for change, openness for digitization, openness for automation and more. More non-technical skills are mentioned in [Maisir19], such as self-awareness, self-organisation, interpersonal skills, intercultural skills, social responsibility and accountability, leadership skills, people management, emotional intelligence, negotiation skills, entrepreneurship, and adaptability.

5.3 The EU-IoT Skills Framework

5.3.1 Overview and Driving Principles

EU-IoT specified its own framework of IoT skills, which structures a set of important and prominent IoT skills in different categories and sub-categories. As such it can be thought as a simple taxonomy of IoT skills. In the scope of EU-IoT, our IoT skills framework has served the following objectives:

- Executing a survey towards understanding the relevant importance of various IoT skills for the market. The survey was structured based on the project's skills framework. Relevant results are presented in the following session.
- Collecting feedback from the IoT and human resources community on the framework towards properly revising the framework. Specifically, as part of the execution of the IoT survey, the project solicited feedback on important IoT skills that were lacking from the survey. This facilitated the revision of the framework based on market feedback.
- Improving the structure and metadata of the EU-IoT training catalogue. Specifically, the EU-IoT framework was used to structure the courses of the catalogue, while enhancing them with metadata relating to the IoT skills that each of the courses' support.

The EU-IoT framework has been developed based on the following principles:

- **Support for technical and non-technical skills**. The framework addresses technical and technological IoT skills, but also non-technical soft skills that relate to IoT skills profiles and roles.
- **Consideration of standards based IoT stacks in the classification of IoT technical**

skills. The framework structures the various technical IoT skills in-line with layered taxonomies of IoT technologies, such as the layers of standards-based IoT stacks like the stack of the Industrial Internet Connectivity Framework (IICF).

- **Classification of non-technical skills**. The framework structures the non-technical skills into various categories such as legal, business, marketing, and social skills.
- **Extensibility**. The framework is destined to provide a way for structuring the various IoT-related skills. However, it provides no exhaustive list of available skills. Interested parties can extend the framework with more skills, while retaining its structure.

5.3.2 Top Level Categorization of IoT Skills

The framework classifies IoT-related skills into four broad categories, namely:

- **IoT Technical and Technological Skills**: This category comprises skills related to IoT technologies, including the skills required to develop, deploy and operate IoT systems. It aims are providing a broad coverage of the very rich set of technologies that are currently associated with IoT systems.
- **Management, Marketing and Regulatory Skills**: This category comprises marketing and management skills that fall in the realm of IoT product and service development. It also includes regulatory related skills such as GDPR (General Data Privacy Regulation) skills and ethics related skills.
- **IoT End-Users and Operator 4.0 skills**: This category consist of skills required for using and operating IoT systems in various sectors of the economy with emphasis on industrial sectors.
- **Social and Soft Skills**: This is the class of soft skills that are important for the development, deployment, operation, and use of IoT systems. It includes popular soft skills life teamwork, lifelong learning and collaboration, which have clear relevance for IoT professionals as well.

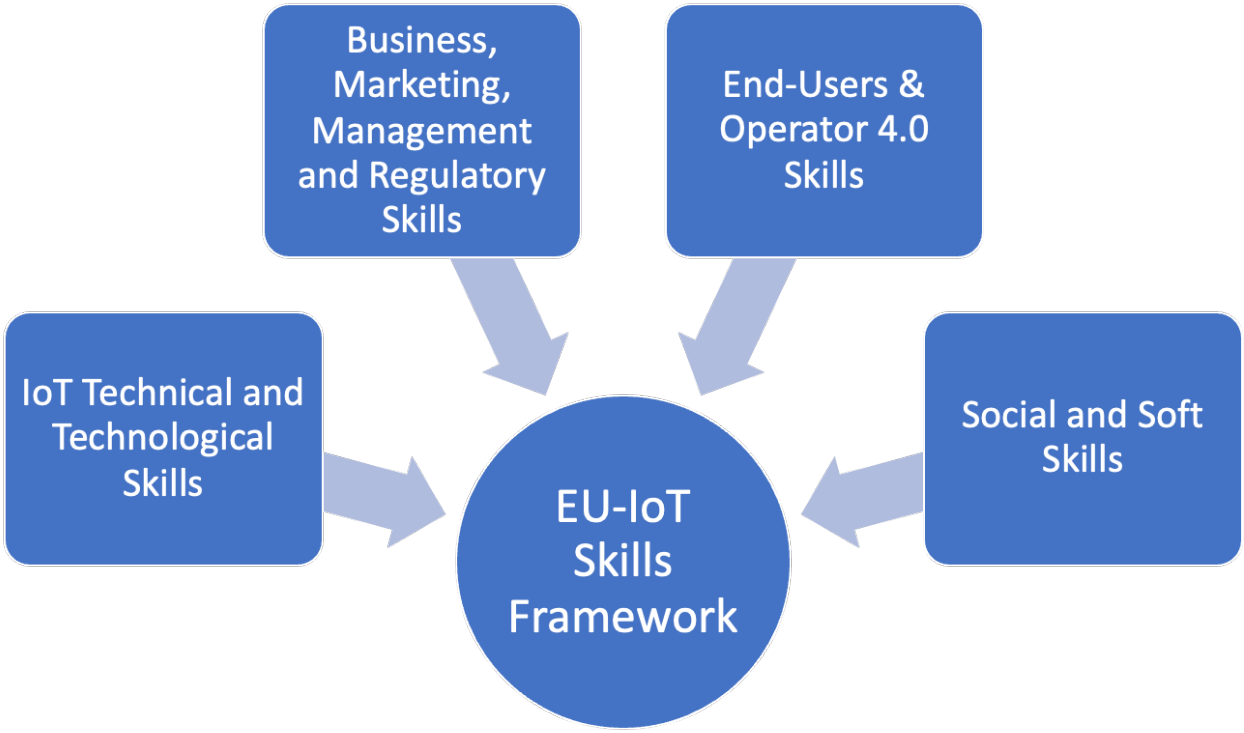

Figure 11: High-Level Taxonomy of the EU-IoT Skills Framework

Each of the four skills categories comprises a rich set of IoT skills, which are structured in sub-categories. The structuring of the various skills provides a sound basis for understanding the types of skills needed for successfully developing, deploying, operating, managing, and monetizing IoT systems. Hence, the various categories provide a good coverage of the various types of IoT skills. Nevertheless, the listed skills provide by no means an exhaustive coverage of all the available IoT skills. As already outlined, interested parties can enhance the framework with more skills by expanding the list of skills that belong to the various (sub)categories.

5.3.3 The Four Categories of IoT Skills

5.3.3.1 IoT Technical and Technological Skills

The IoT technical and technological skills are further segmented to the following sub-categories:

- **IoT devices skills**: This subcategory comprises skills associated with different types of internet-connected devices. Specifically, it includes skills associated with sensors, actuators, digital signal processing (DSP), field programmable gate arrays (FPGA), the Global Positioning System (GPS), programmable logic controllers (PLC), Wireless Sensor Networks (WSN), ad-hoc networks, radio frequency identification (RFID) devices and more. Each one of these skills corresponds to expertise regarding the structure, the computational capabilities, and the networking functionalities of IoT devices.
- **Smart objects skills**: This subcategory complements device-level skills with additional skillsets that correspond to more complex and sophisticated smart devices such as Cyber-Physical Systems and Unmanned Aerial Vehicles (UAVs). In the context of the EU-IoT skills framework, these more sophisticated devices are conveniently characterized as smart objects. The rationale behind distinguishing smart objects from the rest IoT devices

lies in their sophistication, which asks for special skills in developing, deploying, and operating them.

- **Networks and Connectivity**: This part of the IoT technical and technological skills comprises skills associated with various networking and connectivity technologies that support IoT deployments. Our list of skills in this sub-category include the most popular networking protocols and connectivity technologies for IoT systems such as Wi-Fi, Bluetooth and LPWAN (Low Power Wide Area Network) technologies. It also comprises various mobile networking technologies like 4G, LTE (Long Term Evolution), 5G and 6G networking technologies.
- **IoT Protocols**: This subcategory comprises skills associated with various IoT connectivity protocols such as MQTT (Message Queue Telemetry Transport), CoAP and DDS (Data Distribution Service). These skills are essential to the development and deployment of IoT systems, since they abstract the transport of IoT data for the device to the applications that consume the data.
- **Cloud/Edge/Mobile Computing**: Cloud computing, edge computing and mobile computing related skills are important to the development, deployment, and operation of non-trivial IoT systems, such as systems that integrate data and services from multiple distributed IoT devices. Hence this sub-category is devoted to cloud/edge/mobile computing related skills.
- **IoT Analytics**: This subcategory comprises skills that permit the analysis of IoT data using various technologies and techniques such as Machine Learning (ML), Deep Learning (DL) and Artificial Intelligence (AI). A wide array of such skills is nowadays important for IoT systems development and deployment ranging from big data analytics to embedded machine learning and TinyML.
- **IoT Security**: Cybersecurity is a critical element for the safe and reliable deployment of IoT systems. Thus, there is a need for security-related IoT skills, including for example skills relating to security processes (e.g., risk assessment, pen-testing) and to secure operations of various types of IoT devices.
- **IoT Software Programming Skills**: The majority of IoT systems comprise software components. Therefore, software development skills are important for the development of IoT systems and applications. Thus, this sub-category includes the rich set of programming skills that enable the development of the software parts of IoT systems. These skills include for example programming in popular languages like Python, Java and JavaScript, as well as in other specialized skills for the programming of IoT devices e.g., robotics programming and Arduino programming.
- **IoT Development Methodologies**: Many modern IoT products and services are developed and deployed over scalable, distributed infrastructure by distributed development teams. Therefore, the establishment of state-of-the-art development infrastructures and employment of proper development methodologies over them are very important for the deployment and operation of successful IoT services. Hence, this subcategory includes skills associated with mainstream development infrastructures and methodologies that are commonly used by developers and deployers of IoT systems. These infrastructures and methodologies including for example DevOps (Development and Operations), DataOps (Data Operations) and MLOps (Machine Learning Operations) infrastructures.
- **IoT Development and Deployment Tools**: This subcategory includes skills linked to the operation and use of IoT development and deployment tools, such as IDEs (Integrated Development Environments) for IoT development.

These subcategories establish a useful taxonomy of IoT related technical and technological skills, which can be extended with more skills under the specified skills grouping. The specification of

these subcategories was partly driven by popular reference architectures that specify the technical building blocks of modern IoT systems. For instance, the devices, networking technologies and connectivity protocols are building blocks of IoT systems specified in the scope of the Industrial Internet Reference Architecture (IIRA) and the Industrial Internet Connectivity Framework (IICF) of the Industrial Internet Consortium (IIC). Nevertheless, skills related to the technical building blocks identified in these reference architectures have been enhanced with skills pertaining to cloud infrastructures, software engineering and project management methodologies. The latter are not specific to IoT systems only, but rather applicable to a broader range of future internet systems. However, these broader skills are important for the development, deployment and operation of cutting edge IoT system, which is the reason why they have been included in the presented taxonomy.

5.3.3.2 Business, Marketing, Management and Regulatory Skills

As already outlined, the inclusion of this category in the EU-IoT skills framework underlines the importance of marking, management and regulatory skills for tasks like IoT product development. The category comprises skills clustered in two sub-categories, namely:

- **Business, Management and Marketing Skills**: This is a rather broad category that comprises various business, management and marketing skills which pertain to IoT products and services. For instance, it includes project management, product management, marketing and financial management skills.
- **Legal and Regulatory Skills**: This subcategory includes the ever important legal and regulatory skills that are required for developing, deploying and launching enterprise scale IoT products/services with commercial relevance. Such products must adhere to applicable laws and regulations such as the GDPR regarding data management and data protection. Therefore, the subcategory includes skills associated with IoT Ethics, GDPR and other IoT/AI related regulations.

The list of skills in this category has been purposeful kept shorter than the list of technical IoT skills. This reflects the fact that the development and deployment of IoT systems requires primarily technical skills, yet business, management and regulatory skills are important as well. Like in the case of other categories it is possible to extend the taxonomy with more skills of business, management, and regulatory relevance.

5.3.3.3 IoT End-User and Operator 4.0 Skills

This category includes skills that should be possessed by the end users of modern IoT systems. It includes the following subcategories of skills:

- **Industrial Automation Skills**: Industrial IoT (IIoT) systems are usually deployed to support, improve and enhance industrial automation processes in sectors like manufacturing, energy, oil & gas, and mining. Therefore, this subcategory is devoted to industrial automation skills that end-users of IoT systems must possess to successful adopt, use and fully leverage IoT functionalities. Such industrial automation skills include for example skills associated with the use of legacy automation systems and technologies (e.g., PLC, SCADA), as well as with popular industrial processes like quality control and production scheduling. It also includes skills linked to emerging digital enabled industrial automation tools like simulation and digital twins.
- **Asset Management Skills**: Asset management applications are ubiquitous in industrial sectors. They can be found in all industries that must efficiently manage physical assets such as manufacturing, energy and smart buildings. Therefore, end-users of IIoT

applications for asset management should have relevant skills including asset programming, intelligent asset management, equipment maintenance, predictive maintenance and more. The EU-IoT framework includes a special sub-category for these asset management skills.

- **Visualization**: End-users of IIoT applications need to understand and use visualizations of IoT data in industrial contexts. This subcategory is devoted to visualization skills, such as big data visualization, augmented reality (AR), mixed reality (MR), design of ergonomic user journeys and more.

Like in the case of the previous categories and subcategories the list of identified skills is representative of end-user task rather than exhaustive. Interested parties are welcome to extend the framework with more skills when using it.

5.3.3.4 Social, Management, and Other Soft Skills

This category signifies the importance of soft skills for IoT systems development, deployment, and use. It comprises the following sub-categories:

- **Thinking Skills**, such as critical thinking, analytical thinking , and complex problem solving.
- **Social Skills**, such as teamwork, interpersonal skills, and professional ethics.
- **Personal Skills**, such as life long learning, time management, people management and emotional intelligence.

The relevance of soft skills for the development, deployment and use of technology systems and applications goes beyond the scope of IoT systems and technologies. Their inclusion in the framework aimed at ensuring that they are not ignored when developing or seeking for IoT talent.

5.3.4 Using the EU-IoT Skills Framework

5.3.4.1 Stakeholder Groups

The introduced framework is a useful tool for many skills related processes in the IoT ecosystem. Likewise, it can be of great interest to a number of different stakeholders' groups, including:

- **IoT Technology Companies (e.g., IoT vendors, IoT solution integrators)**: These companies can use the framework as part of their hiring and skills development processes. It can serve as a guide for searching for the right talent, evaluating candidate workers based on their IoT knowledge and skills, as well as structuring training and skills development processes.
- **Users of IoT Technology**: The framework can help companies that deploy and use IoT systems to properly shape the training and skills development processes of their digital transformation. The latter training processes should put emphasis on developing or attracting professionals with the right IoT skills to ensure that their investments in IoT technology are effective and yield the best possible ROI (Return on Investment).
- **Policy Makers**: Policy makers can consult our skills framework as part of their policy development processes, notably in terms of educational and training policies. In particular, policy makers could use the framework in conjunction with information about the relevance, the importance and the market demand for each skill, in order to plan effective educational polices that address market needs.

5.3.4.2 Training, Hiring, and Skills Development Processes

The introduced skills framework can be used to support the following processes:

- **Training Processes**: The framework can support the design and development of training programs that lead to the acquisition of certain key skills or even entire skills profiles. It can also help IoT professionals to select a portfolio of courses for developing or strengthening their IoT skills.
- **Hiring Processes**: Human Resources (HR) professionals can consult the framework when implementing hiring processes. Specifically, they can use it to identify the key skills required for specific positions. Moreover, it can help them cluster relevant skills and identifying skills interrelationships. The latter are important when trying to hire or form a cohort of professionals that will staff some IoT-related department or project.
- **Skills Development Processes**: HR experts and individual IoT professionals can leverage the framework when designing skills development journeys. For instance, they can use it to cluster multiple related or complementary skills into skills profiles. Moreover, policy makers can take advantage of the framework in their efforts to introduce new skills development programs that address proven skills gaps in the market.

5.4 The EU-IoT Skills Survey

5.4.1 Survey Identity and Methodology

EU-IoT designed and executed an IoT skills survey which aimed at identifying the IoT-related skills that are high in demand in the IoT market. The rationale behind the design and the implementation of the survey was to identify the IoT-related skills with the highest relevance in the IoT market. In this direction our methodology involved the following steps:

- **Designing the survey in-line with the EU-IoT framework**: The EU-IoT framework was used to structure questions about the IoT skills relevance and importance. Specifically, the survey was segmented into four sub-surveys as per the four top-level skills categories of the EU-IoT framework. Hence, the four sub-surveys concerned technical and technological skills, business and marketing skills, end-users and Operator 4.0 skills, as well as social and other soft skills. Each survey comprised lists of IoT-related skills. Participants were asked to grade the importance of each skill for the IoT market on a scale from 1 (Very Low) to 5 (Very High). Hence, the importance of each skill was indicated by an importance score that was computed based on the total weighted average of the responses.
- **Collecting answers from relevant professionals:** IoT and HR professionals were invited to fill-in the survey. The four different sub-surveys were administrated to different groups of relevant professionals with experience and expertise in IoT skills and IoT projects. For instance, the technical and technological skills sub-survey was answered by IoT professionals with relevant technical experience and expertise, as well as by HR professionals involved in IoT hiring processes. Likewise, the sub-survey on business, management, and marketing skills was answered by a different group that comprised professionals with expertise in IoT marketing, product management and product management. Overall, 70 respondents answered the technical and technological skills sub-survey, 37 respondents answered the business and marketing skills sub-survey, 40 respondents answered the end-users and Operator 4.0 skills sub-survey, and 36

respondents answered the social and other soft skills sub-survey. In total 183 respondents answered the four sub-surveys. The participants come from different industries, including manufacturing, smart cities, energy, agriculture, and security. They also had various profiles and roles including project managers, technical project managers, engineers, data scientists, HR Professionals, developers, architects, researchers, product managers and business development experts. All participants had jobs relevant to IoT and in most cases a strong IoT knowledge and expertise.

- **Analyzing the results and identifying the most popular skills**: The results of each one of the sub-surveys were analyzed to identify the popularity and importance of various IoT skills according to the opinions of the respondents. As already outlined, the relevant importance of each skill was ranked according to the weighted averages of the responses in the given scale. Skills falling within the same subcategory were directly comparable in terms of their importance and market relevance. For instance, the answers to the survey indicate directly the relevant importance of different device-level IoT skills and of IoT analytics related IoT skills. Skills falling in different sub-categories of the same sub-survey (e.g., IoT networking vs. IoT devices skills) can only be indirectly compared.

Sub-Survey	Number of Respondents
IoT Technical & Technological	70
Business, Management, Marketing	37
End-Users and Operator 4.0 skills	40
Social and Other Soft Skills	36
TOTAL	**183**

Table 3: Number of Respondents in the Four Sub-Surveys

5.4.2 Analysis of the Results

5.4.2.1 IoT Technical and Technological Skills Sub-survey

The following figures illustrate the relevant importance of IoT technical and technological skills in the ten different (sub)categories of technical/technological skills of the EU-IoT framework. Figure 12 presents the importance of device related skills. Knowledge and expertise on sensors and sensor networks (e.g., WSN) are considered as most important skills at that level. This is generally expected given their ubiquity in IoT related deployments. Indeed, sensors and WSN span almost all IoT sectors and application areas (e.g., hardware development, software development, middleware development). Other device categories appear less important in general, yet they were perceived very important for professionals in specific industries. This is for example the case with industrial automation devices (e.g., PLC), which were considered very important by manufacturing professionals.

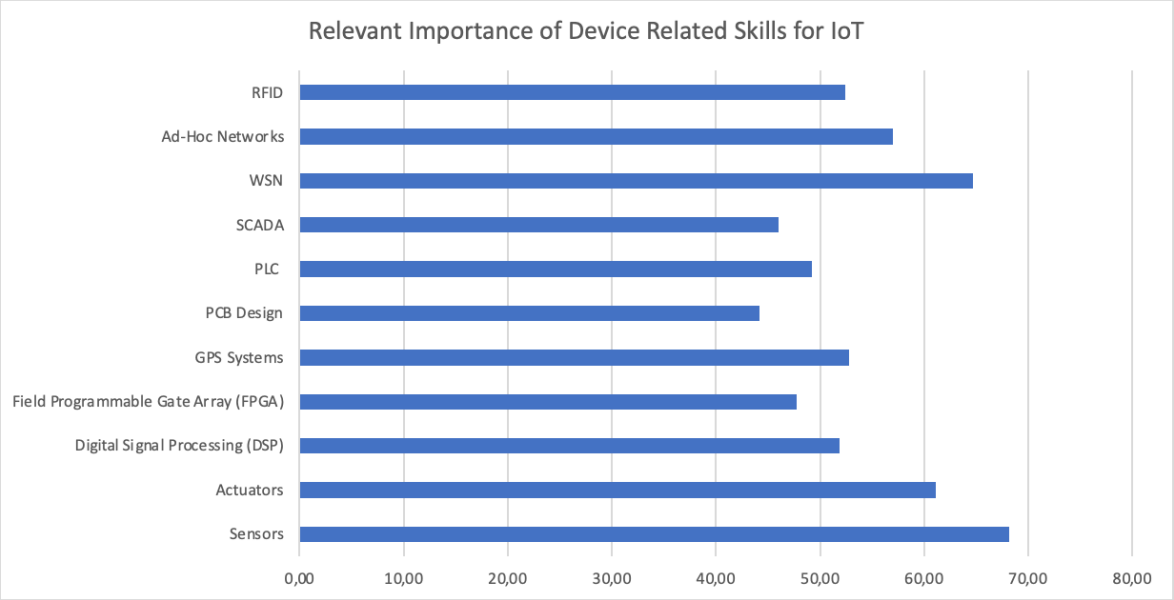

Figure 12: Relevant Importance of Device Related Skills

All smart objects (Figure 13Figure 14) were perceived as important by the respondents. The most popular and widespread ones (i.e., cyber-physical systems, smart wearables) appear as slightly most popular in the survey

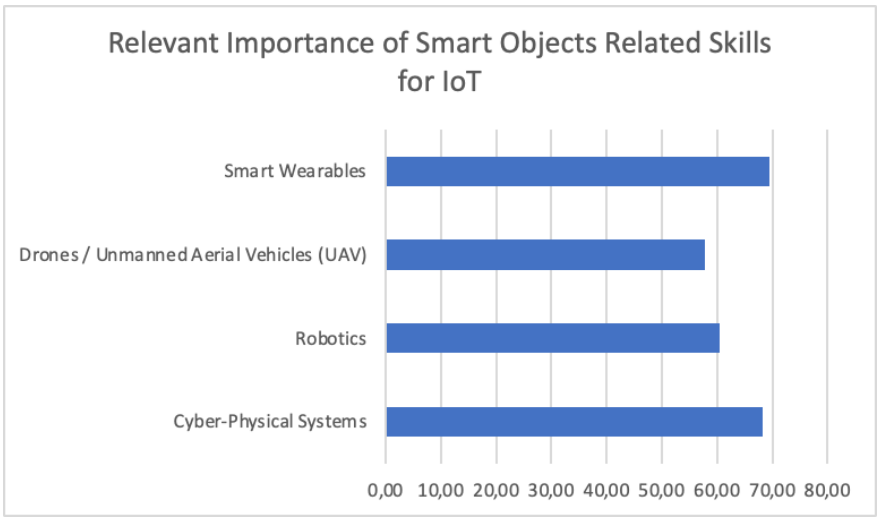

Figure 13: Relevant Importance of Smart Objects Related Skills

Figure 14 presents the survey outcomes about the importance of networking and connectivity technologies. The results seem to follow the evolution of the state of the art. Emerging networking technologies that are tailored to IoT applications (e.g., LPWAN and 5G networks) appear as most popular, along with the most widely used connectivity technologies for IoT applications such as WiFi. IoT connectivity technologies like 6LoPan appear as less important as their popularity is fading.

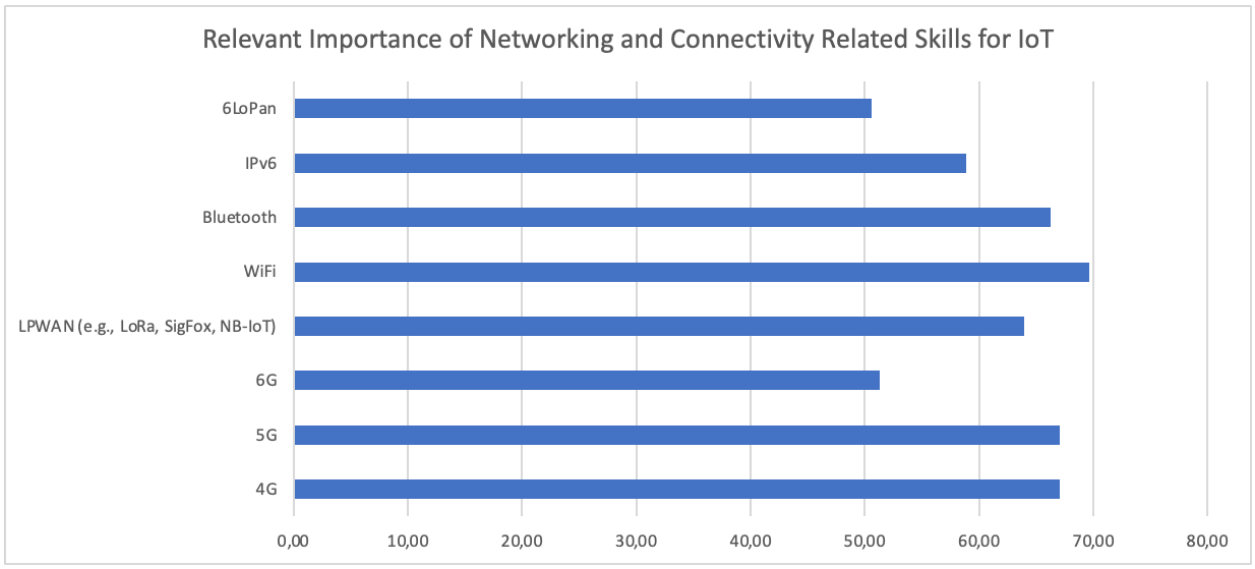

Figure 14: Relevant Importance of Networking and Connectivity Related Skills

Figure 15 ranks skills related to popular IoT protocols. MQTT related skills are ranked as more important than other IoT protocols that are less frequently used (e.g., DDS, OneM2M). Moreover, some protocols rank very high among the responses of the professionals from the sectors where they are used (e.g., OPC-UA is popular within professionals in the manufacturing and other industrial sectors).

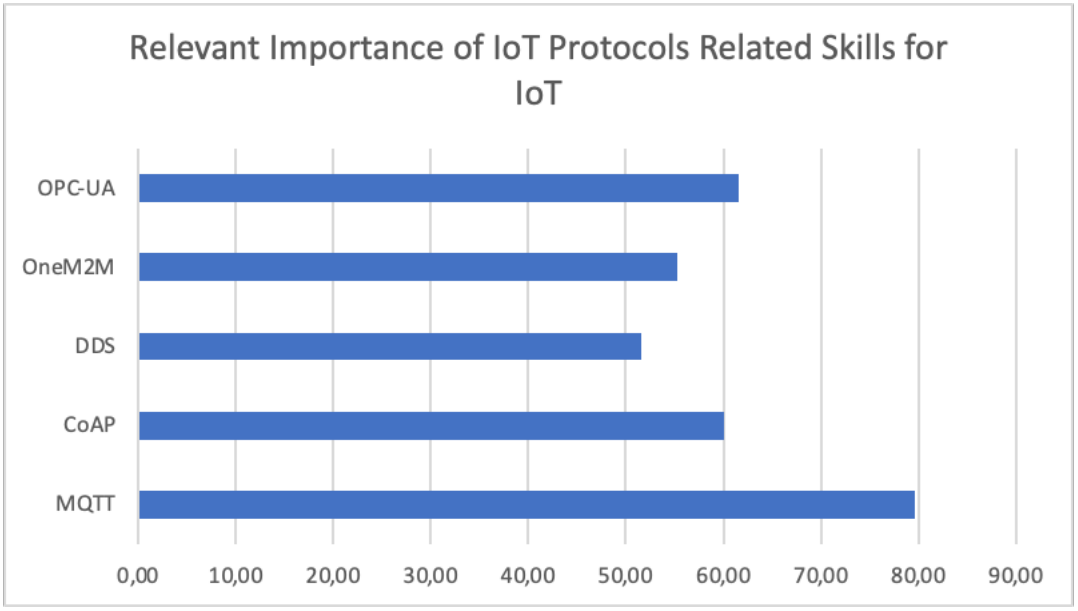

Figure 15: Relevant Importance of IoT Protocols Related Skills

Figure 16 illustrates that IoT skills that are combined with cloud computing and edge computing expertise in a powerful skills combination. This is due to the large number of IoT applications that are integrated in the cloud or follow cloud/edge architectures. Other middleware paradigms (e.g., decentralized IoT applications based on distributed ledger technologies) follow in popularity.

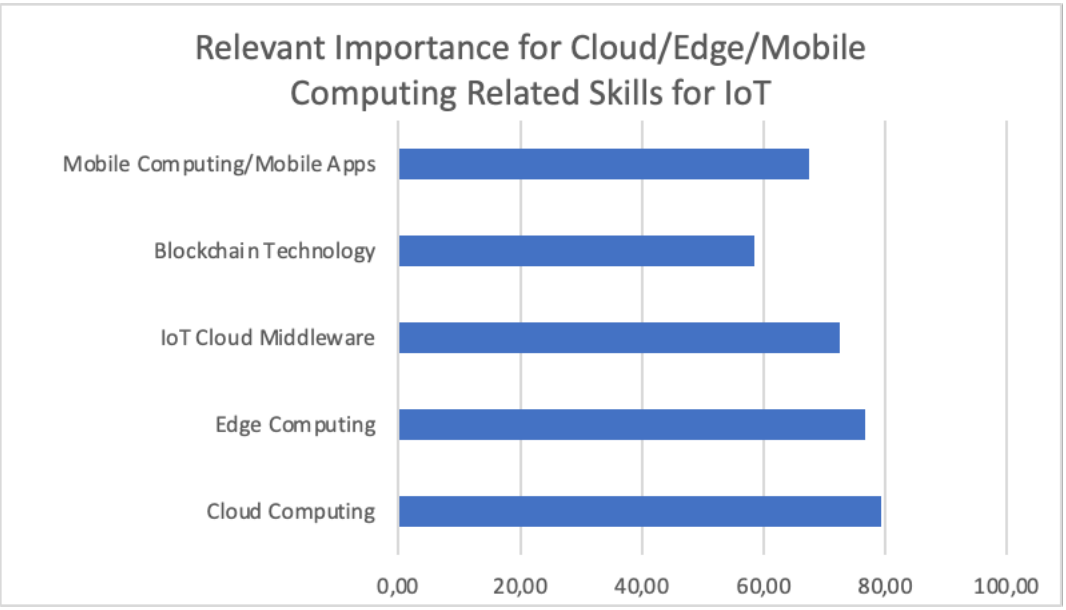

Figure 16: Relevant Importance of Cloud/Edge and Mobile Computing Related Skills

The respondents' opinion on the importance of IoT data analytics technologies (including ML and AIoT related technologies) is illustrated in Figure 17. Mainstream analytics technologies and skills (e.g., Data Science, Machine Learning (ML), Artificial Intelligence (AI)) are perceived as more important than other specialized IoT-related skills (e.g., TinyML). This is probably because IoT analytics paradigms on the device (e.g., TinyML, embedded machine learning) have been around for just a couple of years, whereas conventional ML/AI paradigms are most widespread and popular in the industry. Note that ML is one of the skills with the highest rank across all the different skills of the survey.

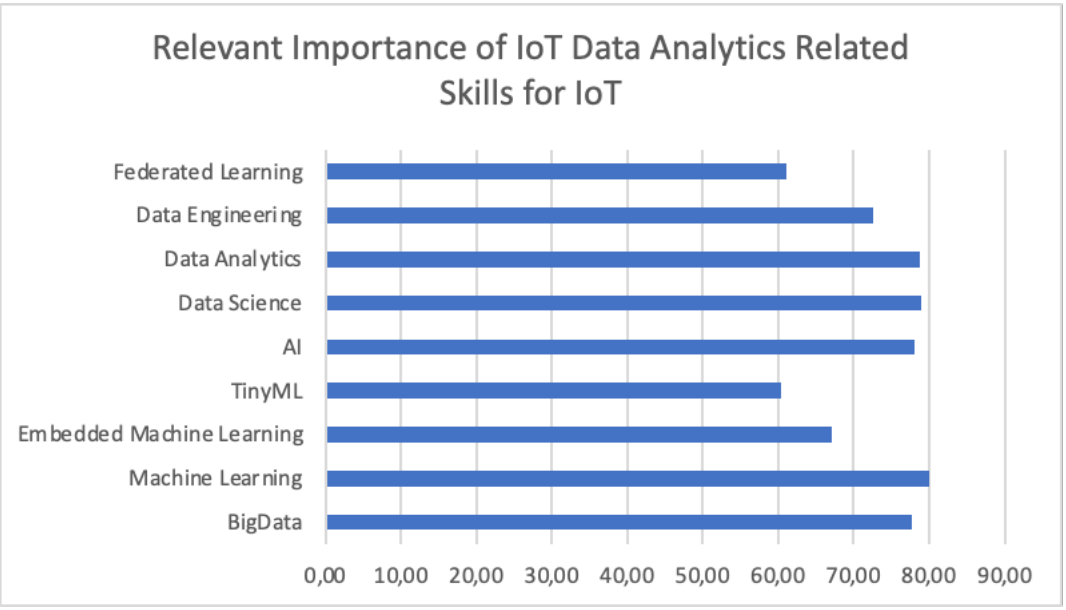

Figure 17: Relevant Importance of IoT Analytics Related Skills

When it comes to IoT, knowledge and skills about the security of IoT assets seem to be more important than more general-purpose cyber-security skills. This is presented in Figure 18, which presents how respondents perceived different security skills in terms of their importance for IoT development and deployment.

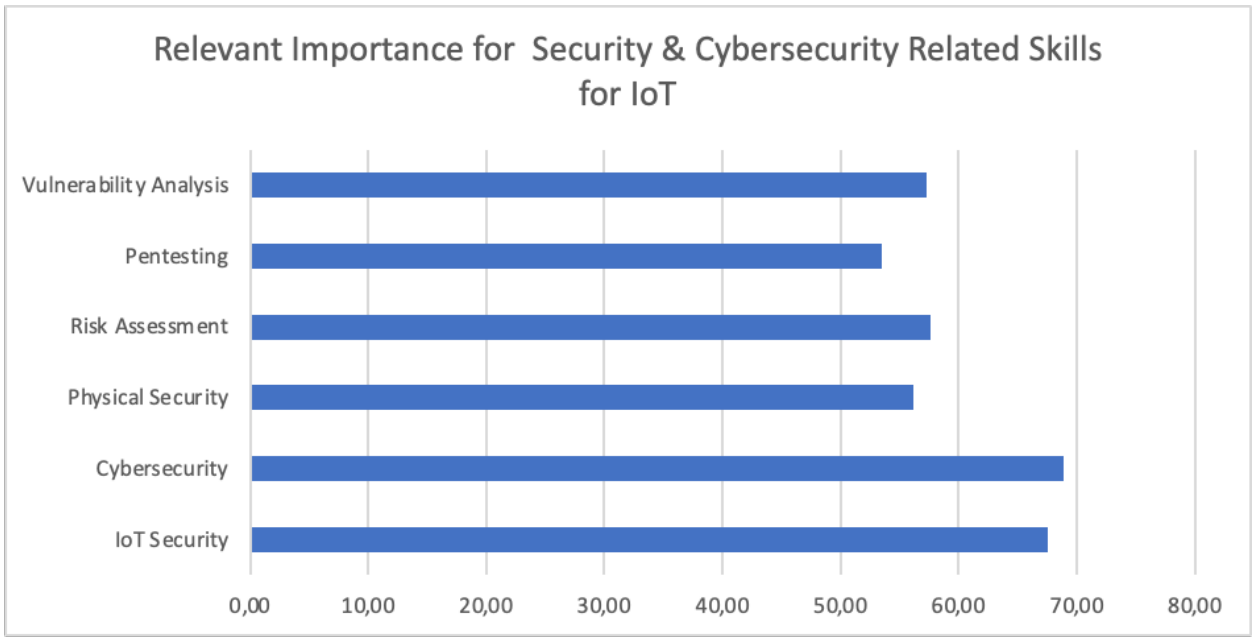

Figure 18: Relevant Importance of Security & Cybersecurity Related Skills

As shown in Figure 19, respondents value general UI/UX skills for IoT application design and development rather than more specialized cyber-visualizations such as Virtual Reality (VR).

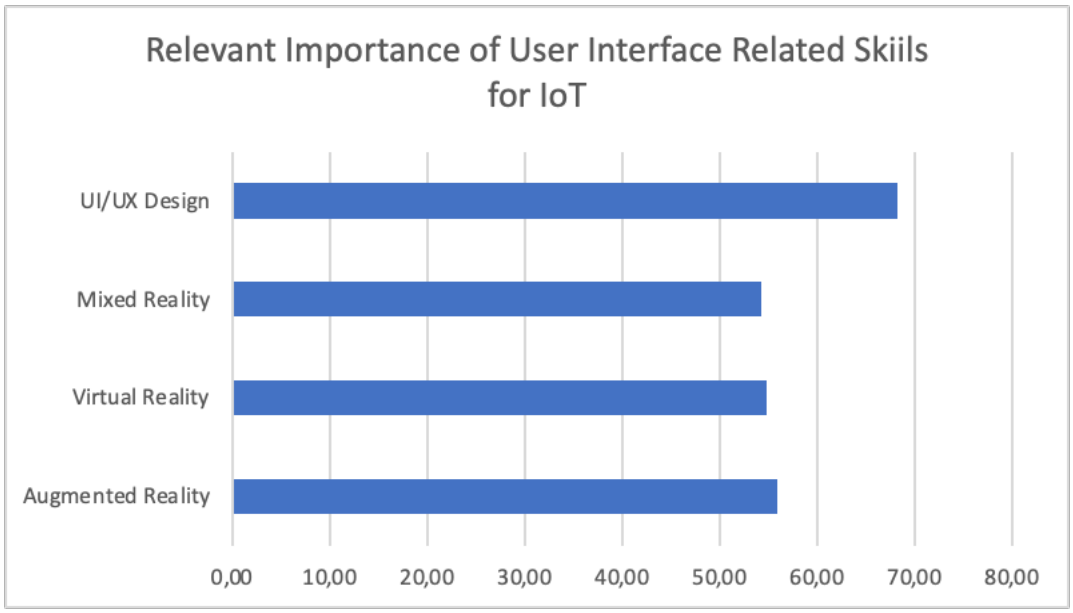

Figure 19: Relevant Importance of User Interface and User Experience Related Skills

Modern non-trivial IoT projects are developed based on agile, iterative methodologies that consider both development aspects and the underlying infrastructure. This is the reason why DevOps skills are deemed as important (Figure 20) and more popular than other methodologies with a more specific scope like MLOps and DataOps.

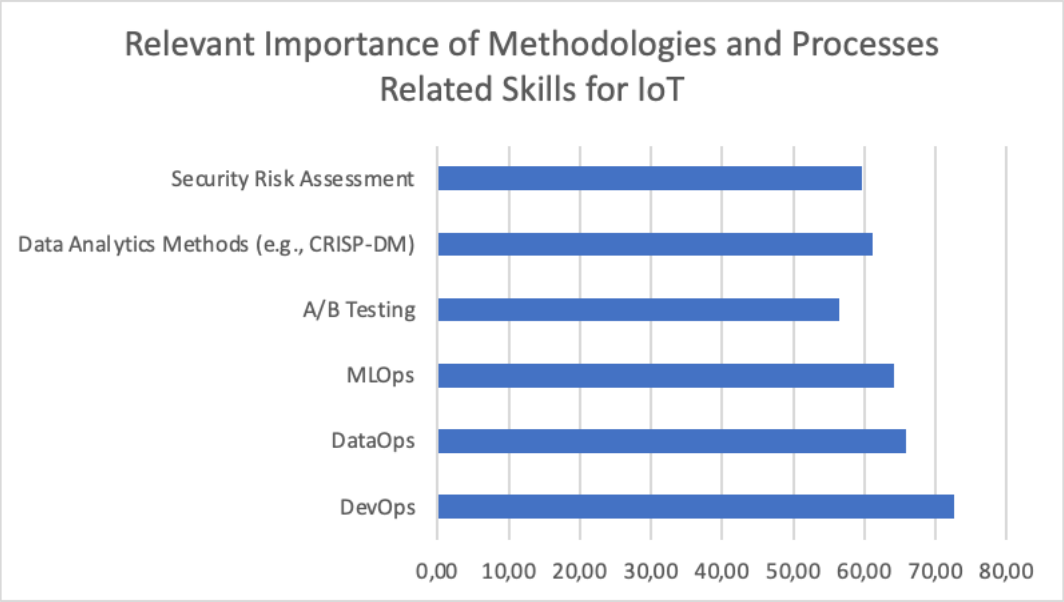

Figure 20: Relevant Importance of Methodologies and Processes for IoT Development Related Skills

Python, JavaScript, Java and C/C++ (in this order) are according to the survey the most important and popular languages for IoT development (Figure 21). This seems to be a reasonable outcome, given that these languages can be used to program the full stack of IoT systems e.g., from embedded devices to the ergonomic dashboards of an IoT application.

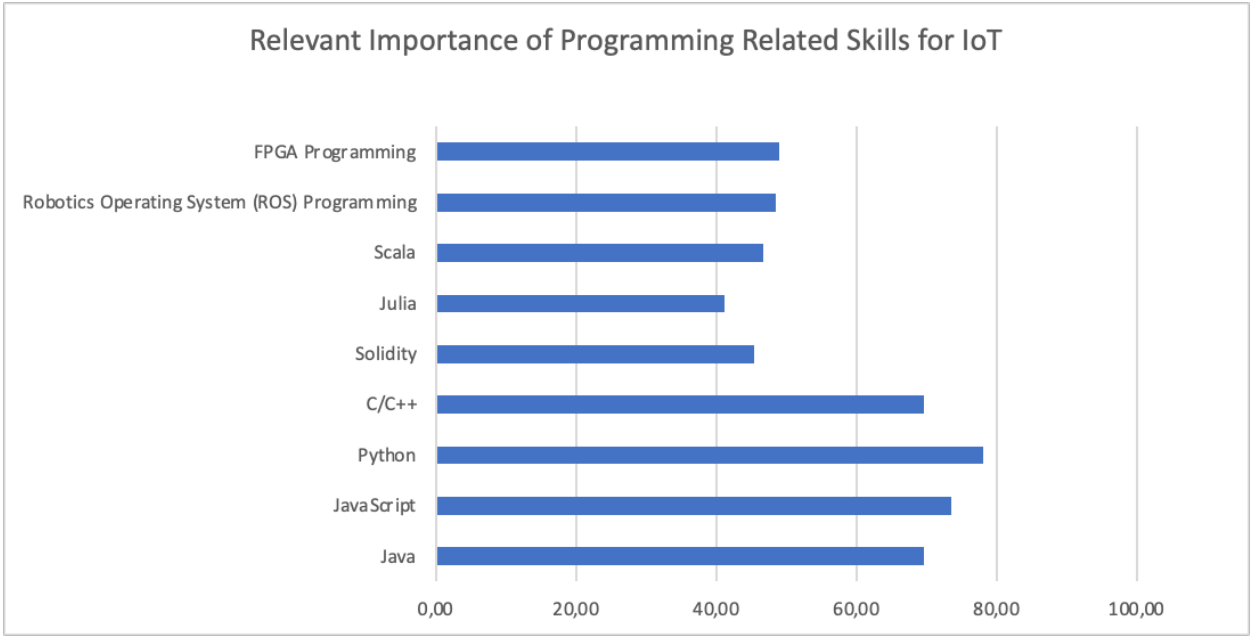

Figure 21: Relevant Importance of Programming Related Skills

Finally, it seems that IoT applications are increasingly developed and deployed in conjunction with modern distributed infrastructure abstraction and workload management technologies like Docker and Kubernetes (Figure 22). This is the reason why these tools are considered important for IoT projects and even more important than specialized IoT tools. Respondents also expressed the importance of integrated IoT development environments in the overall IoT platforms and tools ecosystem. Knowledge of some IDE (Integrated Development Environment) is an important technical skill for certain classes of IoT professionals (e.g., IoT developers).

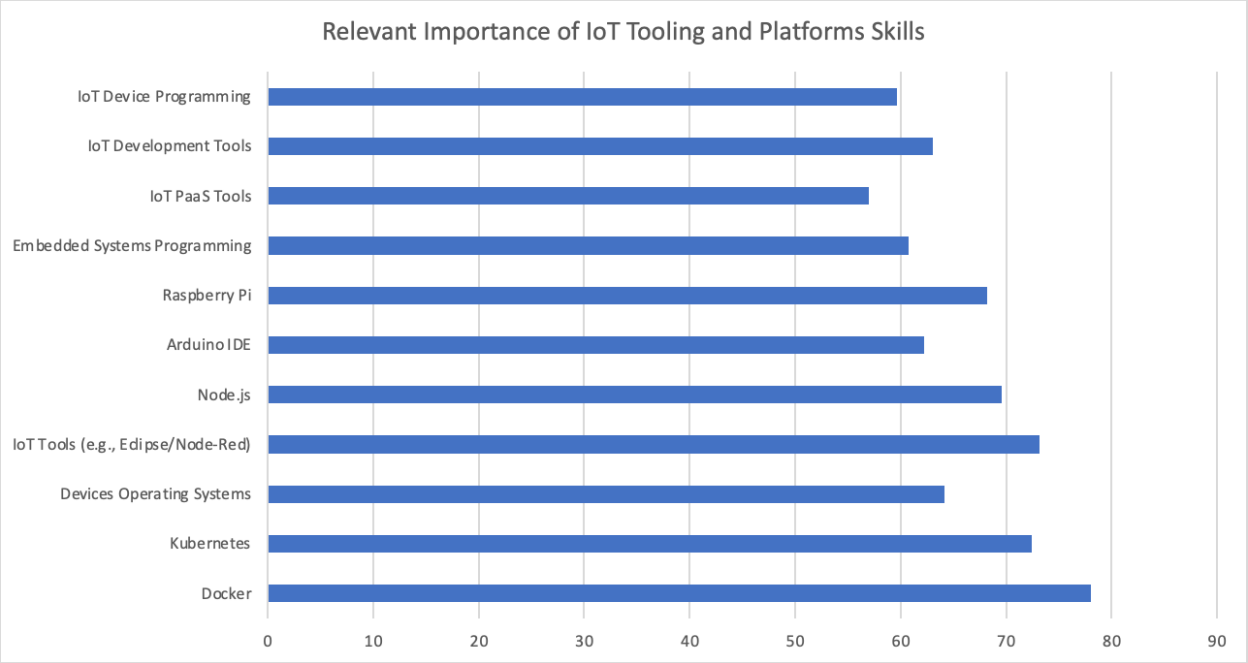

Figure 22: Relevant Importance of IoT Platforms and Tools Related Skills

5.4.2.2 Business, Marketing, Management and Regulatory Skills Sub-survey

The following figures illustrates the respondents' opinion on the relevant importance of the business, marketing, and management skills of the EU-IoT framework. Figure 23 demonstrates that product management and project management are two of the most important skills for IoT professionals. Both have a rank close to 80%. Marketing and finance related skills have a lower rank.

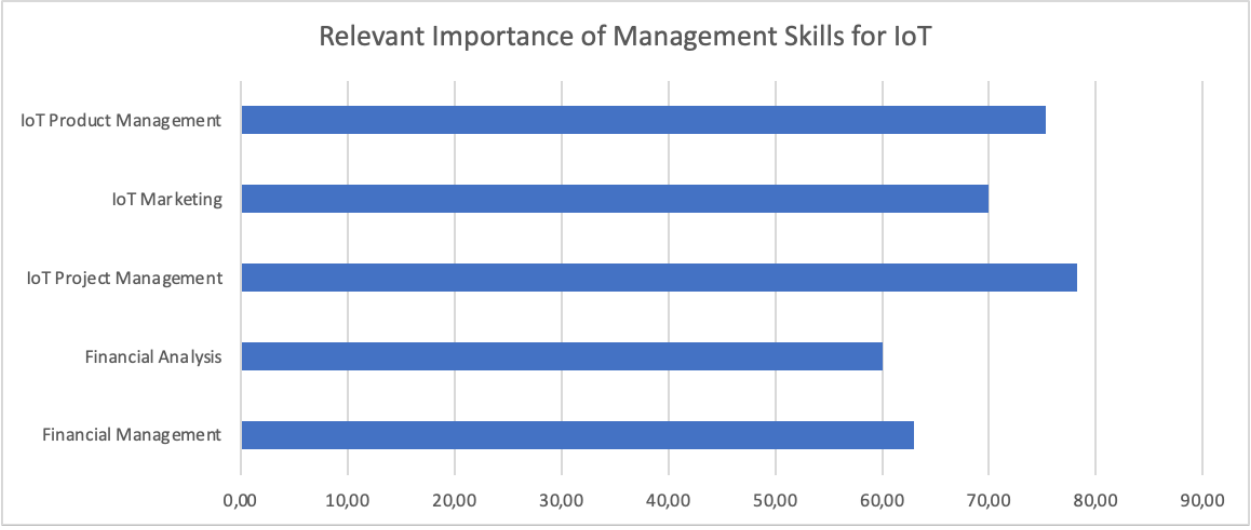

Figure 23: Relevant Importance of Management and Marketing Skills

Figure 24 lists the outcomes of the survey regarding the importance of ethics, legal and regulatory skills. As most respondents were European, GDPR related skills are deemed very important. This is reasonable given that GDPR is a mandatory regulation and that many IoT applications (e.g.,

healthcare applications) handle sensitive data.

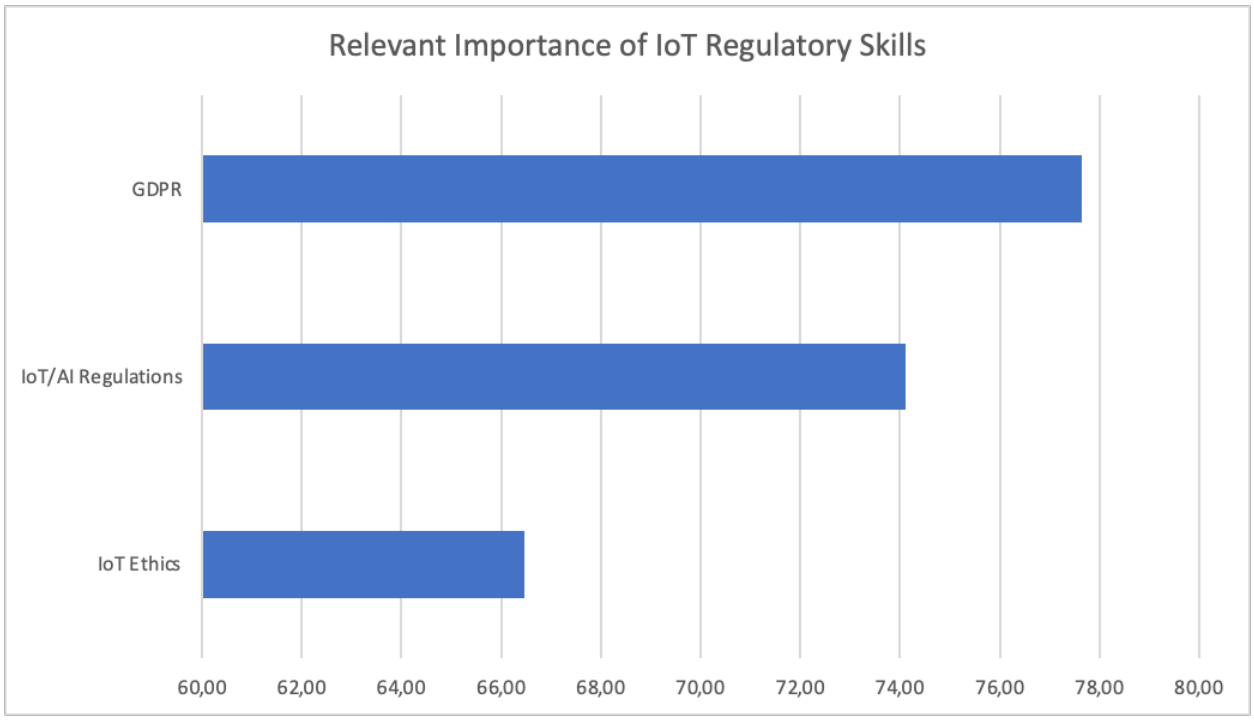

Figure 24: Relevant Importance of Legal and Regulatory Skills

5.4.2.3 IoT End-User and Operator 4.0 Sub-survey

The following figures illustrate the survey outcomes regarding the importance of end-user skills. Figure 25 presents industrial automation skills that are usually important for the development and deployment of industrial IoT applications. Digital twins' skills for IIoT applications were perceived as very important for IoT deployments. Skills related to more specific industrial applications have a lower rank due to their more limited generality and applicability. This is also the reason why simulation skills were ranked in the second position of the skills importance.

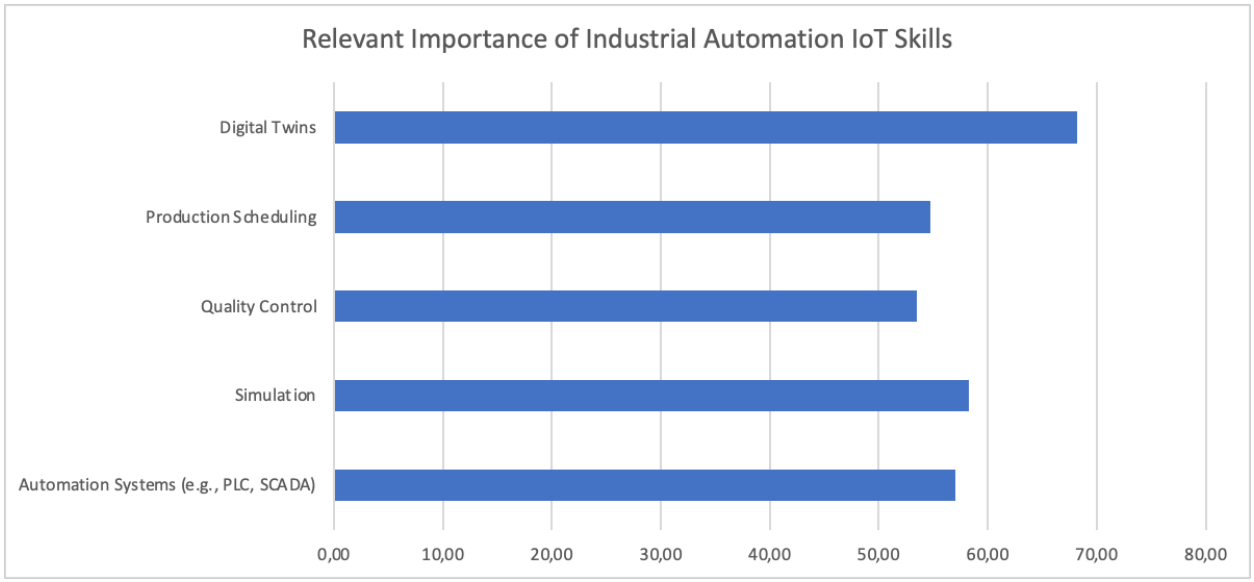

Figure 25: Relevant Importance of Industrial Automation Skills

Figure 26 presents the respondent's perceived importance of asset management skills. The outcomes confirm that predictive maintenance and intelligent asset management are considered among the most prominent industrial IoT applications.

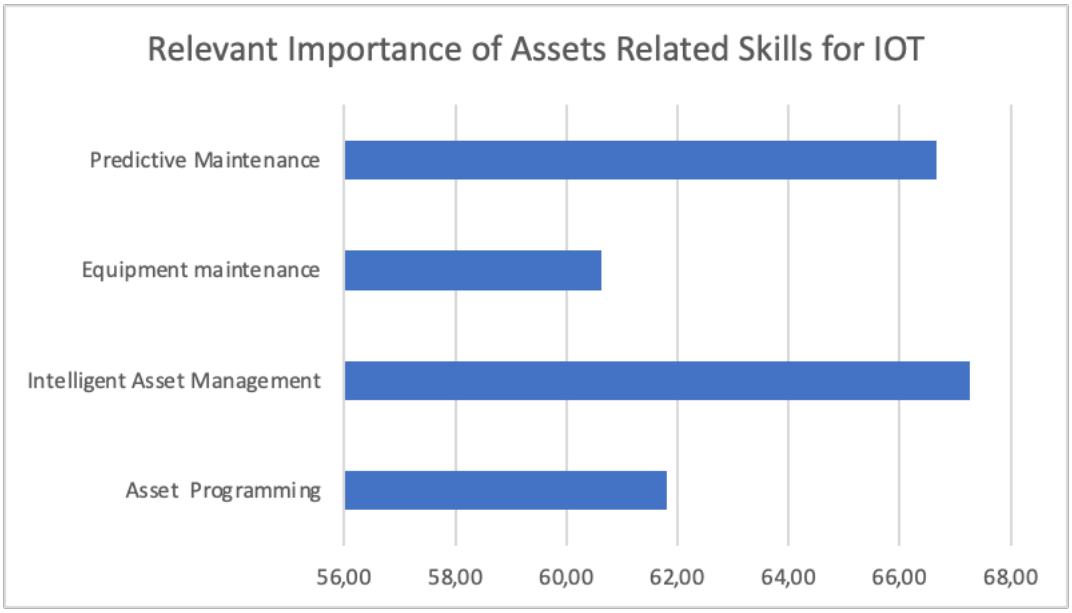

Figure 26: Relevant Importance of Asset Management Skills

The survey also targeted the ranking of various data and visualization related skills for IoT applications (Figure 27). Big data visualization is considered a very important skill with broad applicability. Human centered technologies (e.g., ergonomic user interfaces) follows in the skills ranking.

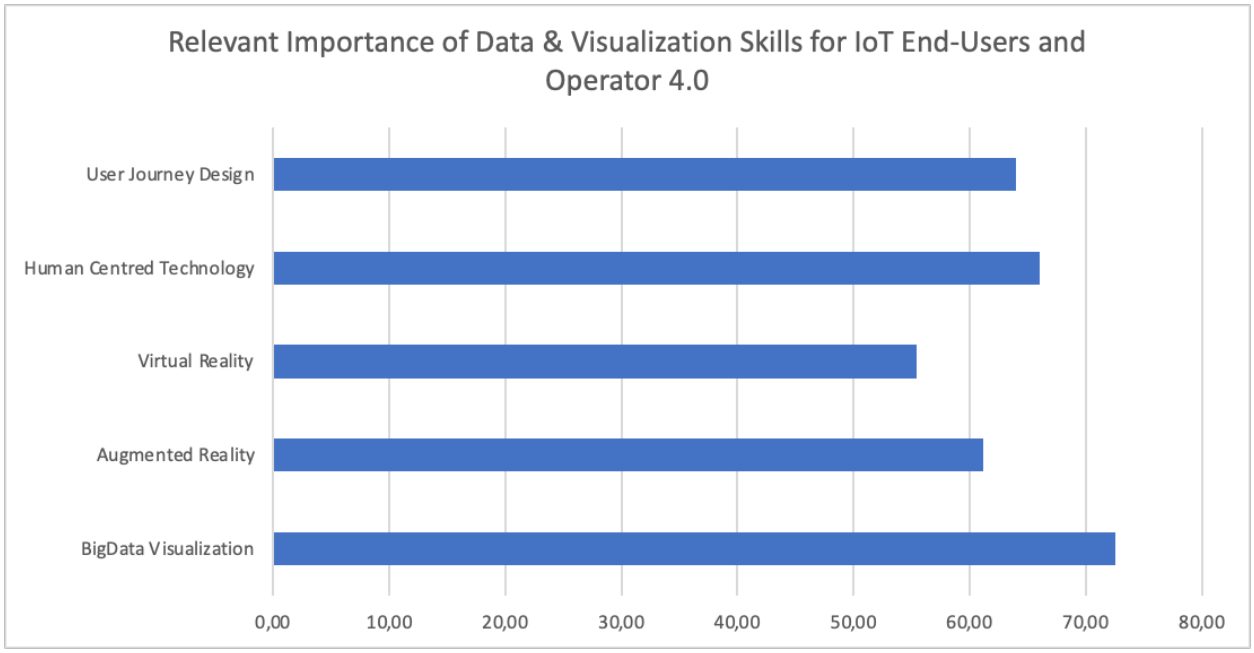

Figure 27: Relevant Importance of Data and Visualization Skills

5.4.2.4 Social, Management, and Other Soft Skills Sub-survey

The following diagrams present the respondents' ranking of thinking, social and personal skills for IoT development. These sets of skills are considered as complementary to technical and management skills. In terms of thinking skills, collaboration was perceived as the most important skill followed by analytical thinking (Figure 28). Both skills play a significant role in the development and deployment of IoT applications.

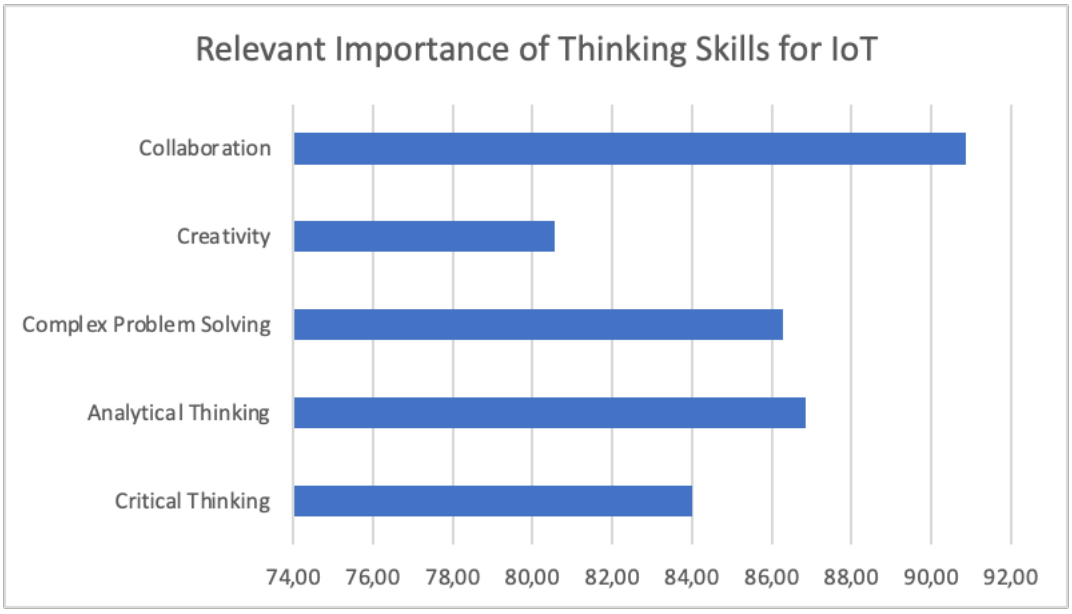

Figure 28: Relevant Importance of Thinking Skills

Figure 29 illustrates the relevant importance of various social skills for IoT. Teamwork is considered very important, which matches the findings of thinking skills where collaboration was prioritized.

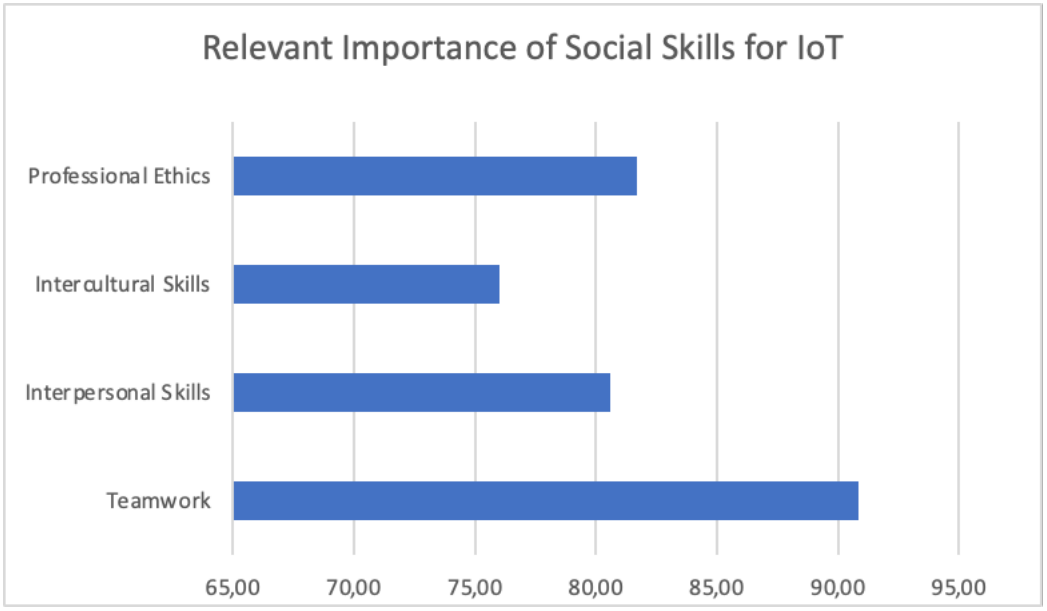

Figure 29: Relevant Importance of Social Skills

Lifelong learning was ranked as the most important personal skill for IoT developments and

deployments. However, many other personal and soft skills (e.g., time management, emotional intelligence) were also considered of importance with quite similar scores (Figure 30).

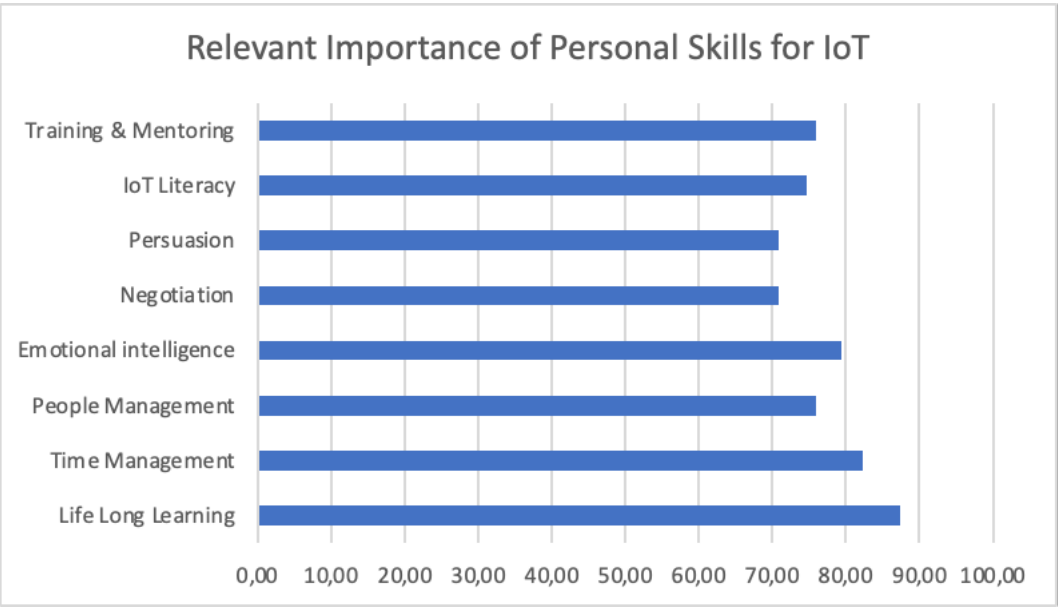

Figure 30: Relevant Importance of Personal Skills

5.4.3 Discussion of Survey Findings

The results of the survey indicate some of the most popular IoT skills according to the opinion of IoT professionals from different sectors. The popularity of the skills is closely linked to the market demand for these skills. However, beyond the overall ranking of the individual skills, there are several useful findings that stem from the analysis of the responses of specific subgroups such as professionals in individual sectors. The main findings from the survey are as follows:

- **The most general and broadly applicable skills are the most popular as well**: The most popular skills were the ones that are broadly used in the scope of IoT systems and applications. This is because these skills enable professionals to engage in a wide range of IoT projects and activities.
- **Specialized skills are important for specific segments and groups of IoT professionals**: More specialized IoT skills are perceived as being very important for professionals within specific sectors. For instance, there are skills ranking very high within manufacturing (e.g., PLC) and skills that rank very high within sectors that handle sensitive data (e.g., healthcare).
- **Several soft Skills (e.g., lifelong learning) are very important**: Soft skills are a very important asset that complements the IoT technical and technological skills. Several soft skills ranked very high in the overall standings of the skills that were included in the survey. Specifically, there many skills that were graded over 70% in the scale of the survey's importance. Successful IoT professionals cannot afford to ignore soft skills.
- **The survey enables different approaches for clustering skills into skills profiles**: The skills survey can be used as a tool for clustering individual skills into skills profiles. In particular, one can set criteria on the ranked skills in order to associated them with skills profiles. A set of concrete and practical ways to do this is provided in the next section.

6 INITIAL ANALYSIS OF IOT LEARNING PATHS

6.1 Skills Profiles and Learning Path Construction Methodology

To excel in the development, deployment, and use of IoT systems and applications workers need more than IoT skills. For instance, IoT technical experts possess several of the previously presented skills from a single sub-category. As a prominent example, an IoT developer is likely to know more than one programming languages to excel in the programming of the IoT Stack. However, it is also common that IoT professionals possess technical skills from different sub-categories of technical skills, such as programming skills and skills relating to IoT protocols like MQTT and CoAP. Therefore, in most cases IoT professionals match entire skills profiles that comprise multiple skills from different technological areas as well as non-technical skills (e.g., the ever-important soft skills).

The clustering of multiple IoT skills into skills profiles is very important for training and skills development processes. The latter are usually driven by the need to develop professionals that possess groups of relevant skills that enable them to undertake roles such as IoT software developer, IoT data engineer, IoT software engineer, IoT systems architect, embedded systems developer and more. The EU-IoT skills framework can support the construction of skills profiles by facilitating interested stakeholders in selecting the skills to be clustered from a rich set of well-structured IoT skills. In particular, using the framework stakeholders can easily identify available skills and how they relate to each other. Hence, they can structure relevant skills profiles that meet the needs of their organizations. There is a variety of different skills profiles such as hardware designers, embedded firmware developments, IoT networking experts, IoT solution integrator, IoT applications front end developers, IoT data scientists, IoT automation engineers and 100s more.

A skills profile can drive the specification of learning pathways (i.e., collections of courses and other didactic activities) that lead to the acquisition of the skills of a profile. These learning pathways can form the basis of entire training programs at academic or professional levels. The simplest form of a learning pathway specifications involves the structuring of a set of courses within a training program.

EU-IoT provides three powerful tools that facilitate the construction of skills profiles and learning paths:

- **The EU-IoT skills framework**, which facilitates the construction of coherent skills profiles that comprise well-structured and complementary collections of courses.
- **The EU-IoT survey,** which can drive the specification of skills profiles subject to criteria like the overall popularity of certain skills, their relevant to specific industries (e.g.., manufacturing), as well as their complementarity. For instance, the most popular IoT analytics related technical skills can be used to form an IoT data scientist skills profile. As another example, a collection of popular methodologies (e.g., DevOps), tools (e.g., NodeRed), programming languages (e.g., Python) and devices (e.g., sensors, WSN) related skills can serve as basis for the specification of an IoT developer profile.
- **The EU-IoT training catalogue,** which provides a pool of training resources that can be used to specify training programs that lead to the key skills of a given skills profile. Specifically, with a skills profile at hand, interested stakeholders can consult the IoT training resources catalogue to identify a concrete set of available courses that can be structured in a learning pathway for the given skills profile.

6.2 Sample IoT Learning Paths

The following tables provide six concrete examples of skills profiles, along with the skills they comprise. They also provide an indicative set of courses that can support the developments of the proper skills for each profile. The listed courses can be found in the Udemy training ecosystem and the EU-IoT training resources catalogue. Specifically, each of the table presents the following information for each one of the six skills profiles:

- **Individual Skills of the Profile**: This is the list of skills that an IoT professional must possess in order to qualify for roles associated with the skills profile. The presented lists are indicative. In principle, it is possible to broaden the scope of a skills profile by including additional skills in the list. As already outlined, the development of skills profile could consider the results of our survey towards including both relevant and popular skills in the profile.
- **Courses of the Learning Path**: This field includes a list of courses that can help professionals learn the listed skills. The tables include courses from the EU-IoT training catalogue and the Udemy training ecosystem. These courses are considered mandatory for acquiring the skills that are mandated by the skills profile. There is a variety of equivalent or similar courses in the training catalogue and in other ecosystems (e.g., Coursera, EdX) that could help building similar learning paths. In principle, the development of a proper learning path can be challenging process that should seek for the optimal complementarity and compatibility of the selected courses.
- **Other Relevant Courses**: This field includes additional courses that could strengthen the learning path for the skills profile as hand. These courses could be considered as optional or "nice to have" for the target profile. Similar to the case of mandatory courses, the tables include courses from the EU-IoT training catalogue and the Udemy training ecosystem. However, there is a variety of equivalent or similar courses in the training catalogue and in other ecosystems (e.g., Coursera, EdX) that could help providing alternative collection of optional courses in order to strengthen the learning path.
-

IoT Skills Profile: IoT Application Developer
Individual Skills of the Profile
Python, JavaScript, IoT & Cloud Computing, DevOps, Docker, Kubernetes, Sensors, WSN, Arduino, MQTT
Courses of the Learning Path
1. Practical IoT Concepts-Devices, IoT Protocols & Servers DevOps **2. Introduction to IoT Programming with JavaScript** **3. Exploring AWS IoT** **4. Project - 2022: CI/CD with Jenkins Ansible Kubernetes** **5. Arduino For Beginners - 2022 Complete Course**
Other Relevant Courses
1. Collaboration and Emotional Intelligence **2. I.T. Project Management for Beginners: A Step-by-Step Guide**

Table 4: Skills and Learning Path for the "IoT Application Developer" Skills Profile

IoT Skills Profile: IoT Networking Engineer
Individual Skills of the Profile
Sensors & IoT Devices, LPWAN, 4G/5G/6G, WiFi, Bluetooth, MQTT
Courses of the Learning Path
1. Internet Of Things (IoT) - Demystified using 3 IOT devices **2. 5G Masterclass: Architecture, NR RAN, Core and Call flows**

3.	**The Ultimate WLAN and WiFi Training Course**
4.	**The Complete Bluetooth / IoT Design Course for iOS**
Other Relevant Courses	
1.	**Collaboration and Emotional Intelligence**
2.	**I.T. Project Management for Beginners: A Step-by-Step Guide**

Table 5: Skills and Learning Path for the "IoT Networking Engineer" Skills Profile

IoT Skills Profile: IoT Data Analytics Expert	
Individual Skills of the Profile	
Data Science, Machine Learning, TinyML, Sensors, WSN	
Courses of the Learning Path	
1.	**Master Machine Learning and Data Science with Python**
2.	**Intro to Embedded Machine Learning**
3.	**Sensors/Actuators/Data Visualization with Microcontrollers - IoT Dashboard with Arduino**
Other Relevant Courses	
1.	**Statistics for Data Science and Business Analysis**
2.	**Collaboration and Emotional Intelligence**

Table 6: Skills and Learning Path for the "IoT Data Analytics Expert" Skills Profile

IoT Skills Profile: Embedded Systems Engineer	
Individual Skills of the Profile	
Embedded Systems, FPGA, PCB Design, Sensors, Actuators, WSN	
Courses of the Learning Path	
1.	**Mastering Microcontroller and Embedded Driver Development**
2.	**Learn the Fundamentals of VHDL and FPGA Development**
3.	**Sensors/Actuators/Data Visualization with Microcontrollers - IoT Dashboard with Arduino**
4.	**Crash Course Electronics and PCB Design**
Other Relevant Courses	
1.	**Arduino: Electronics circuit, PCB Design & IOT Programming**
2.	**Collaboration and Emotional Intelligence**

Table 7: Skills and Learning Path for the "Embedded Systems Engineer" Skills Profile

IoT Skills Profile: IoT Project Manager	
Individual Skills of the Profile	
Project Management, Sensors, WSN, DevOps, Agile Development	
Courses of the Learning Path	
1.	**I.T. Project Management for Beginners: A Step-by-Step Guide**
2.	**Agile PM 301 - Mastering Agile Project Management**
3.	**Project - 2022: CI/CD with Jenkins Ansible Kubernetes**
4.	**Sensors/Actuators/Data Visualization with Microcontrollers - IoT Dashboard with Arduino**
Other Relevant Courses	
1.	**Presentation Skills: Master Confident Presentations**
2.	**Management Skills - Team Leadership Skills Masterclass 2022**
3.	**Collaboration and Emotional Intelligence**

Table 8: Skills and Learning Path for the "IoT Project Manager" Skills Profile

IoT Skills Profile: IoT Product Manager	
Individual Skills of the Profile	
Product Management, Sensors, WSN, Cyber-Physical Systems	
Courses of the Learning Path	
1.	**Agile PM 301 - Mastering Agile Project Management**
2.	**Great Product Manager: Product Management by a Big Tech's PM**
3.	**Complete Guide to Build IOT Things from Scratch to Market**
4.	**Sensors/Actuators/Data Visualization with Microcontrollers - IoT Dashboard with Arduino**
Other Relevant Courses	
1.	**Presentation Skills: Master Confident Presentations**
2.	**Management Skills - Team Leadership Skills Masterclass 2022**
3.	**Advanced Product Management: Vision, Strategy & Metrics**

Table 9: Skills and Learning Path for the “IoT Product Manager” Skills Profile

Overall, the tables provide a set of representative examples that aim at illustrating the process of specifying learning paths based on available catalogues of training resources. There is however much room for interested stakeholders to fine-tune the learning paths development process by scrutinizing the vast amount of training resources that are already available towards identifying their optimal complementarity and selecting the resources that are most appropriate for training an IoT professional in the key skills of a given profile.

7 CONCLUSIONS

This deliverable has reported on the EU-IoT training and skills development activities, which were implemented during the first two years of the project's lifetime. The activities included the collection of available training courses, the organization of training webinars in trending IoT topics, the development of a taxonomy of IoT skills, the conduct of an IoT skills with the participation of over 100 IoT professionals, as well as the creation of an initial set of IoT skills profiles and of accompanying learning paths. These activities have already led to the production of tangible and exploitation outcomes, including:

- A catalogue of IoT courses, which enables interested stakeholders to discovery and access IoT training resources through a single-entry point.
- A collection of on-line webinars, including their recordings and the training materials that they comprised. This collection of webinars can be used to complement other training resources with information and materials about cutting edge IoT technologies.
- A skills framework that provides a taxonomy of IoT skills, including technical, technological, management, marketing, and end-users skills for IoT systems and projects. The skills framework is a useful resource for a variety of stakeholders (e.g., IoT training policy makers, human resources professionals), since it enables stakeholders to combine IoT skills into skills profiles.
- A skills survey that identifies the relevant importance of different IoT skills according to the opinion of over IoT professionals that participated in the survey.
- A set of IoT skills profiles and accompanying learning paths, which illustrate the process of leveraging available courses and training resources in order to support IoT professionals in acquiring the IoT skillsets needed for a specific role.

In the remaining months of the project, EU-IoT will focus on enhancing the above-listed results, while at the same time disseminating them to the IoT community and boosting their adoption and use. Specifically, the project will disseminate information about the EU-IoT skills framework and the results of the project's skills survey by means of a publicly accessible whitepaper. Likewise, the results of the survey, the skills framework and some indicative skills profiles will be promoted through the regular dissemination activities of the project such as the EU-IoT events (workshops) and the project's social media posts. Moreover, the project will solicit experts' feedback about the importance of various IoT skills profiles in order to identify and structure relevant and effective learning paths. Expert feedback will be also exploited in order to enhance and improve the EU-IoT skills framework through extending it with new skills and updating the structure of some of the existing skills categories.

EU-IoT will also focus on the provision of learning paths of certified knowledge i.e., learning paths that lead to the acquisitions to various certifications for specific skills. Such learning paths will be promoted by the project as "certified" learning paths. Accordingly, they will be exploited towards boosting certified knowledge among the European IoT community. The certification activities of the project will be reported in the final deliverable of the project in the series of training and skills development activities (i.e., deliverable D4.5). The latter deliverable will provide more insights in the definition of skills profiles and learning paths, which is currently work in progress.

Most importantly, EU-IoT will intensively pursue the sustainability and wider use of the training and skills development results of the project. Given the proclaimed gaps in IoT skills, the above-listed EU-IoT results could have a significant impact in the European IoT ecosystem.

APPENDIX A: CONCLUDED TRAINING WORKSHOPS INFORMATION

1. Seminar Title: "AIoT and Edge Machine Learning"

(*Unleashing the Power of IoT Analytics at the Edge)*

Training Workshop Agenda

Friday, 21 May 09.30-12.00 CEST

09:30 - 09:40	**"Introduction to the Topic and the Workshop"**, John Soldatos, INTRASOFT International, EU-IoT
09:40 - 10:00	"**Introduction to Federated Learning**", Marcin Paprzycki, Polish Academy of Sciences, ASSIST-IoT
10:00 – 10:20	"**Cybersecurity Contexts of Federated Machine Learning",** Artemis Voulkidis, Synelixis Solutions S.A, IoT-NGIN
10:20- 10:40	"**Federated Machine Learning at the Edge**", Arne Bröring and Sumudu Samarakoon, SIEMENS, IntelloT
10:40- 10:45	**Break**
10:45- 11:05	"**Accelerated Deep Learning for Cognitive Edge Computing**", Jens Hagemeyer, Bielefeld University, VEDLIoT
11:05- 11:25	**"Applications of Machine Learning and Edge Computing in Maritime Logistics"** Jussi Poikonen, Awake.AI, iNGENIOUS
11:25- 11:40	"**Tools and Techniques for Embedded Machine Learning and TinyML development**", John Soldatos, INTRASOFT International, EU-IoT
11:40 - 11:55	**Questions & Answers from Participants**
11:55 - 12:00	**Training Workshop Closing**

2. Seminar Title: "Enabling the Tactile Internet with IoT"

(*How IoT can Break Time & Space Boundaries)*

Training Workshop Agenda

Thursday, July 8thth, 2021 (12.00-14.30) CEST

12:00 - 12:05	**"Introduction to the Topic and the Workshop"**, John Soldatos, INTRASOFT, EU-IoT Project
12:05 - 12:30	**"AR enterprise applications powered by XR streaming"**, Luis Bollinger, Holo-Light, Gmbh, IntelliIoT Project,
12:30 - 12:55	"**AR+VR for remote control over Tactile Internet**", Cristina Escribano, NOKIA, iNGENIOUS Project
12:55- 13:20	"**Use of Tactile Internet and Augmented Reality in the Construction Industry**", Piotr Dymarski, Mostostal, ASSIST-IoT Project
13:20- 13:45	**"Designing IoT-powered XR services and applications towards a Tactile Internet",** Stavroula Bourou, Synelixis Solutions SA, IoT-NGIN Project
13:45-14:10	**"Cross-layer framework for tactile applications",** Ahmad Nimr, TU Dresden, iNGENIOUS Project
14:10 - 14:25	**Questions & Answers from Participants**
14:25 - 14:30	Conclusions & Workshop Closing

3. Seminar Title: "Machine Learning at the Edge and the Far-Edge" (organized in the scope of the 2021 IoT Week (online event))

Training Workshop Agenda

Monday, August 30th, 2021 (11.45-12.45) CEST

11:45 - 12:05	**"Introduction to Federated Machine Learning (FL) and FL Cybersecurity",** Dr. Artemis Voulkidis, Synelixis Solutions SA, H2020 IoT-NGIN Project
12:05 - 12:25	**"VEDLIoT – A heterogeneous hardware platform for next-gen AIoT applications Teaching the IoT to learn",** Dr. Jens Hagemeyer, University of Bielefeld, H2020 VEDLIoT Project
12:25 - 12:45	**"TinyML: AIoT and Machine Learning at the FAR-EDGE",** Dr. John Soldatos, INTRASOFT International S.A, EU-IoT Project

4. Seminar Title: "Next Generation IoT Architectures"

Training Workshop Agenda

Tuesday, November 9th (12.00-14.40) CET

12:00 - 12:05	**"Introduction to the Topic and the Workshop"**, EU-IoT
12:05 - 12:15	**"Overview of Standards Based Reference Architectures for IoT"**, Dr. John Soldatos, EU-IoT
12:15 - 12:35	"**IoT-NGIN Meta-Architecture**", Dr. Artemis Voulkidis, H2020 IoT-NGIN Project Technical Coordinator
12:35 - 12:55	"**iNGENIOUS: An IoT Architecture for the Universal Supply Chain**", Dr.-Ing. Carsten Weinhold, H2020 iNGENIOUS Project
12:55- 13:15	"**TERMINET: A Next-Generation IoT Reference Architecture**", Prof. Panagiotis Sarigiannidis, H2020 TERMINET Coordinator
13:15 - 13:25	Break
13:25 - 13:45	"**The ASSIST-IoT Architecture**", Prof. Carlos Palau, H2020 ASSIST-IoT Project Coordinator
13:45 - 14:05	"**IntelIIoT's architectural vision in alignment with W3C WoT**", Dr. Konstantinos Fysarakis and Dr. Soumya Kanti Datta, H2020 IntelIIoT Project
14:05 - 14:25	**""VEDLIoT Toolchain for Efficient Deep Learning on heterogenous hardware**", Hans Salomonsson, H2020 VEDLIoT Project
14:25 - 14:35	Questions and Answers – Discussion
14:35 – 14:40	Conclusions & Workshop Closing

5. Seminar Title: ““Decentralizing IoT Intelligence using Distributed Ledger Technologies”

Training Workshop Agenda

Monday, February, 07th (9.00-11.00) CET

9:00 - 9:10	**“Introduction to the Topic and the Workshop - Blockchain’s Potential for IoT”**, EU-IoT Project
9:10 - 9:25	**“DLT-enabled security for IoT infrastructures”,** Ioardanis Papoutsoglou, ASSIST-IoT Project
9:25 - 9:50	**"Interledger and Self-sovereign identities",** Dmitrij Lagutin, IoT-NGIN Project
10:50- 10:15	**“Leaving breadcrumbs of key information over different DLTs: TrustOS platform and CrossDLT”,** Carlos Alcaide Pastrana, iNGENIOUS Project
10:15- 10:40	**“Auditing & data integrity in IoT installations using DLT”,** Giorgos Siachamis TERMINET Project
10:40- 10:50	**Questions & Answers from Participants**
10:50 - 10:55	**Conclusion & Workshop Closing**

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